DEVELOPMENT OF AN EMBEDDED SYSTEM FOR REAL TIME MONITORING OF MINING PROCESSES

A Thesis submitted in partial fulfilment of the Requirements for the degree of

Master of Technology
In
Electronics and Communication Engineering
Specialization: VLSI Design & Embedded Systems

By
Naresh Thakur
Roll No.: 213EC2213

Under the Guidance of
Prof. Debiprasad Priyabrata Acharya

Department of Electronics and Communication Engineering
National Institute of Technology Rourkela
Rourkela - 769 008, India

Dedicated to...

My parents, My Dear Friends

And NIT Rourkela

Department of Electronics & Communication Engineering
NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA
ODISHA, INDIA – 769 008

CERTIFICATE

This is to certify that the thesis titled **"DEVELOPMENT OF AN EMBEDDED SYSTEM FOR REAL TIME MONITORING OF MINING PROCESSES"** submitted to the National Institute of Technology, Rourkela by **NARESH THAKUR**, Roll No. **213EC2213** for the award of the degree of **Master of Technology** in **Electronics & Communication Engineering** with specialization in **"VLSI Design and Embedded Systems"**, is a bonafide record of research work carried out by him under my supervision and guidance. The candidate has fulfilled all the prescribed requirements.

The thesis, which is based on candidate's own work, neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere. To the best of my knowledge, the thesis is of standard required for the award of the degree of **Master of Technology** in Electronics & Communication Engineering.

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Dept. of Electronics & Communication Engg.
National Institute of Technology
Rourkela-769 008 (INDIA)

DECLARATION

I certify that

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Naresh Thakur

30th May 2015

ACKNOWLEDGEMENTS

It is my immense pleasure to avail this opportunity to express my gratitude, regards and heartfelt respect to Prof. D. P. Acharya, Department of Electronics and Communication Engineering, NIT Rourkela for his endless and valuable guidance prior to, during and beyond the tenure of the project work. His priceless advices have always lighted up my path whenever I have struck a dead end in my work. It has been a rewarding experience working under his supervision as he has always delivered the correct proportion of appreciation and criticism to help me excel in my field of research.

I would like to express my gratitude and respect to Prof. K. K. Mahapatra, Prof. A. K. Swain, Prof. M. N. Islam and Prof. P. K. Tiwari for their support, feedback and guidance throughout my M. Tech course duration. I would also like to thank all the faculty and staff of the ECE department, NIT Rourkela for their support and help during the two years of my student life in the department.

I am also very thankful to all PHD scholars, especially Mr. Debasish Nayak and Mr. Umakanta Nanda who always encouraged me in the Successful completion of my thesis work.

I would also like to thank my junior Himanshu Sekhar Pradhan for his continuous support and help throughout the project work.

Finally I would like to thank all my classmates, especially Nitin Jain, Santosh Kumar Padhy, Ashutosh Kumar Singh and Sarika Anil Kumar for their continuous support and help.

Naresh Thakur

nareshthakur199@gmail.com

ABSTRACT

In an opencast mine the raw materials are carried out by using the dumpers. So these dumpers need to be monitored right from their loading point to their destination point. The commercially available vehicle tracking systems use GSM (Global System for Mobile Communications)/GPRS (General Packet Radio Service) network for the communication. But in the opencast mines there may be a problem of accessing the standard GSM network. So the previously available tracking systems cannot provide uninterrupted service. The tracking system designed here tracks and monitors the vehicles moving inside the opencast mines without any interruption. It is using the GPS (Global Positioning System) receiver (for getting the location and time information about the vehicles), GSM (Global System for Mobile Communications)/GPRS (General Packet Radio Service) network (For long range data communication) and Zigbee module (For short range data communication). The GSM module is sending the data to the internet and this data is then given to a GIS (Graphical Information System). The Graphical Information System will display the vehicle location inside the mine. The Zigbee module will be used for data transmission when GSM signal is not available. A switchover module will be placed at a location in the mine where GSM signal is available. The switchover module will receive the data sent by the Zigbee and give it to GSM module. Because of the use of short range communication device (Zigbee), this system can track the vehicles even at the positions where GSM Network is not available.

Contents

List of Figures

List of Tables

1. INTRODUCTION

1.1. Introduction

Opencast mines are dug on benches, which describe vertical levels of the hole. An open cast mine means the mine which is open to air. The raw materials of these mines are carried by the vehicles called dumpers. The dumpers take the raw materials from the digging point and dump it at a particular area. So an embedded system should be developed which will give the detail location information about the vehicles moving in an opencast mine. This information will be gathered in the control room so that a person sitting in the control room can have an eye on these vehicles. If any of the vehicle stops moving then the person sitting in the control room can immediately contact to the person inside the vehicle and finds the solution for its problem.

An embedded system is a computer system with a dedication function within a larger mechanical or electrical system, often with real time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. A modern embedded system basically consists of a microcontroller and other peripheral devices required for performing a dedicated function. The embedded system required to meet the requirements of the open cast mine will consists of electronic and electrical components.

1.2. Motivation

In mining process a common challenge is to monitor the moving vehicles such as dumpers. These vehicles need to be tracked from their loading point to their destination point. The commercial vehicle trackers were used previously which were not meeting all the requirements of the mines. Basically, the commercial vehicle trackers use GSM network for communication. The GSM network may have weaker strength at various places in the mines so tracking the vehicles at those places is very difficult. There may be network failure for some period. Because of these problems the commercially available Vehicle tracker could not provide uninterrupted services. So there is a need to develop an embedded system which will provide uninterrupted services at every place in a mine.

1.3. View of an open cast mine

Figure 1.1 View of an open cast mine

Figure1.1 Show the view of an open cast mine. It shows the digging point, the vehicles carrying the raw materials and the path in which the vehicles move and go towards the dumping area.

1.4. Specific requirements of the mine

In the iron ore mines there are many dumpers are involved for dumping the raw materials in the dumping area. For the effective utilization of these moving vehicles, they can be monitored right from their point of loading to their destination point. So a system is required to do the following tasks

- Monitoring the movement of the vehicles inside the control room.

- Checking whether the vehicle has gone through the weigh bridge or not.
- Providing the exact direction to the vehicles.
- Getting information from the vehicles, if any problem occurs.

1.5. Proposed solution

The existing vehicle tracking systems use GSM network for communication. There are many places in the mines where we do not have an access to GSM network so the existing systems fail to track the vehicles at those locations. There also may be a problem of GSM network failure for some days. So to overcome these problems we are using the GSM system along with a short range communication device.

1.6. Objective

1. To develop a hardware system for installing inside the vehicle.
2. To develop software for configuration and proper operation of the hardware installed inside the vehicle.
3. To develop software for receiving the data sent by the hardware installed inside the vehicle.
4. To develop a database for storing the data sent by the hardware installed inside the vehicle.
5. To develop software for displaying the location of the tracked vehicles.
6. To provide communication between the tracked vehicles and the control room.

1.7. Block diagram of the proposed system

The complete block diagram of the proposed system is shown in figure 1.2. It consists of following blocks.

1. Vehicle Unit
2. Switchover Unit
3. Web Server
4. Graphical Information System

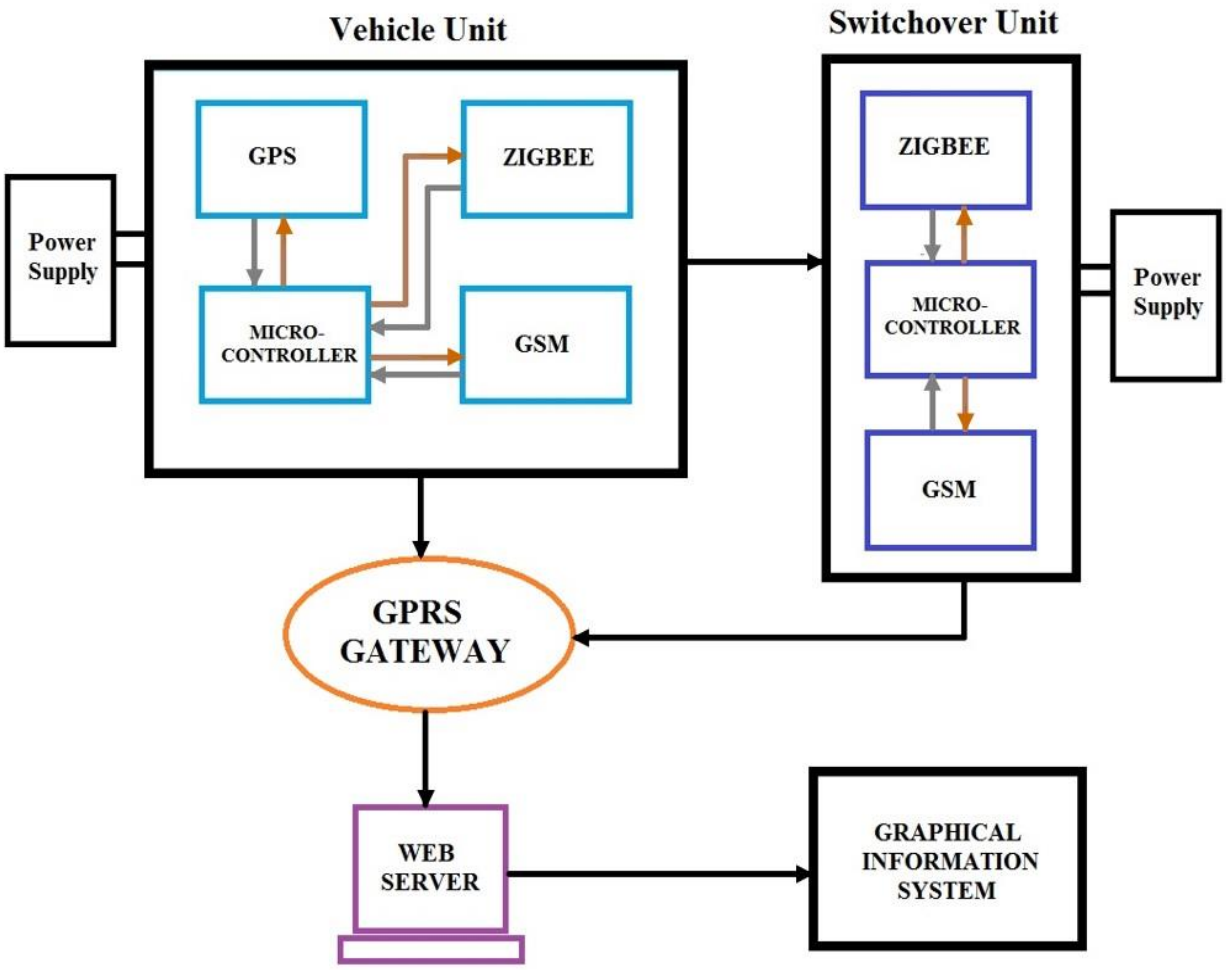


Figure 1.2 Block Diagram of the proposed system

1.7.1. Vehicle unit

This is the unit placed on the vehicle. We have to track the location of this unit and hence the vehicle. The block diagram of the vehicle module is shown in the figure no. It consists of following parts

1. GPS module
2. Arduino board
3. GSM module
4. Zigbee module
5. Power supply unit

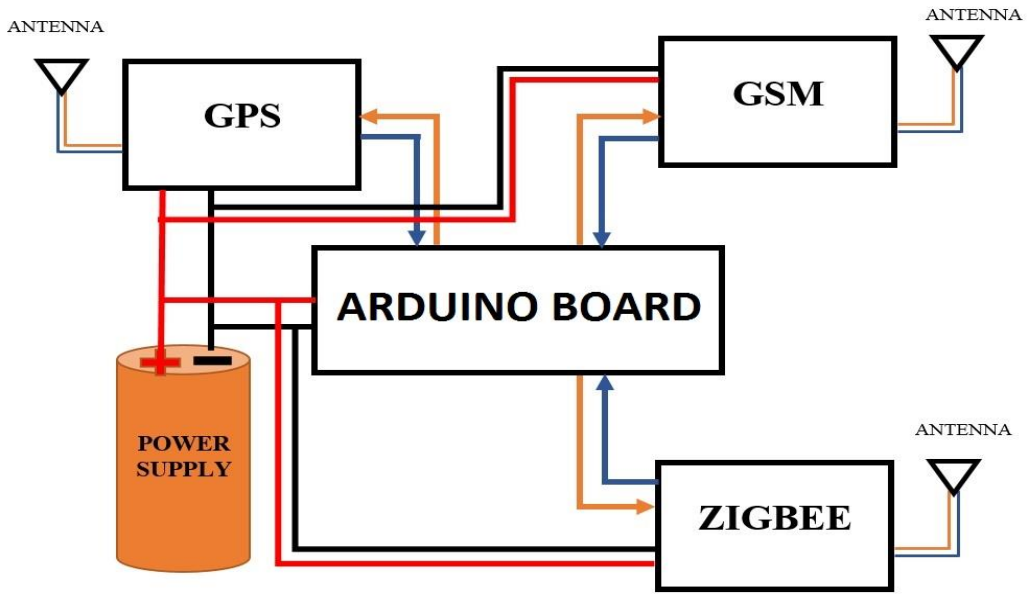


Figure 1.3 Block Diagram of the Vehicle Unit

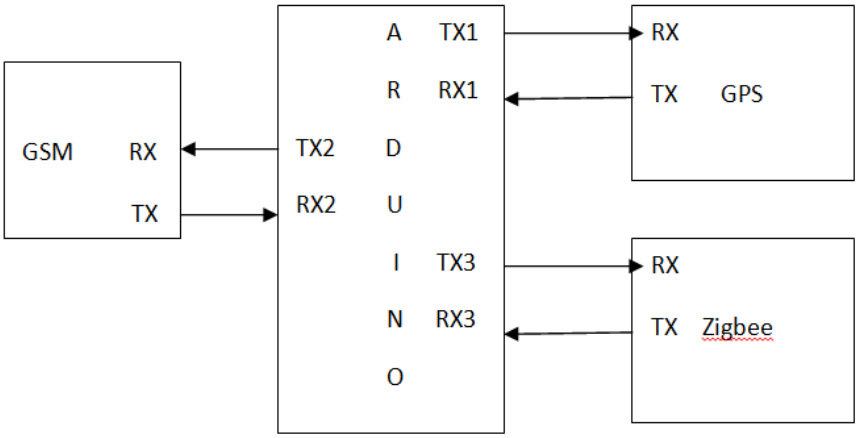


Figure 1.4 Diagram showing Communication among Different Modules in Vehicle Unit

a. GPS module

Here the GPS Module will receive the location information from the satellite. The GPS receiver will receive this information through an external antenna as shown in figure no. The GPS module will now communicate serially with the Arduino board. As shown in the figure no. the Serial communication pins TX and RX of the GPS module is connected to the RX1 and TX1 pins of the Arduino board respectively for communicating serially with each other.

b. Arduino board

The Arduino board will receive the GPS data. Now it will extract the required information from the raw GPS data. The TX2 and RX2 pins of Arduino board is connected to RX and TX pin of GSM module as shown in figure no.. The Arduino board will now check the availability of the GSM netwotk. If GSM network is available it will give the data to GSM module otherwise to Zigbee module.

c. GSM module

It is used for sending the data to the web server. It will receive the data from Arduino board and send it to the web server through GPRS gateway. It also uses an external antenna for sending the data.

d. Zigbee module

It is used for sending the data when GSM network is not available. It receives the data from Arduino board. The TX3 and RX3 pin of Arduino board is connected to the RX and TX pins of Zigbee. It can send up to short range. It sends the data to the Zigbee module present in the Switchover unit. Its range depends on the external antenna.

e. Power supply unit

It supplies power to all the modules present in the Vehicle unit. The Arduino board, GSM module and GPS module require an input voltage of 5v. But, the Zigbee module requires an input voltage of 3.3V. So the power supply unit must have to supply two different values of input voltages.

1.7.2. Switchover unit

The switchover unit is used when GSM Network is not available at the Vehicle location. The switchover unit should be placed at a location where GSM Network is available. The block diagram of Switchover unit is shown in Figure 1.5.

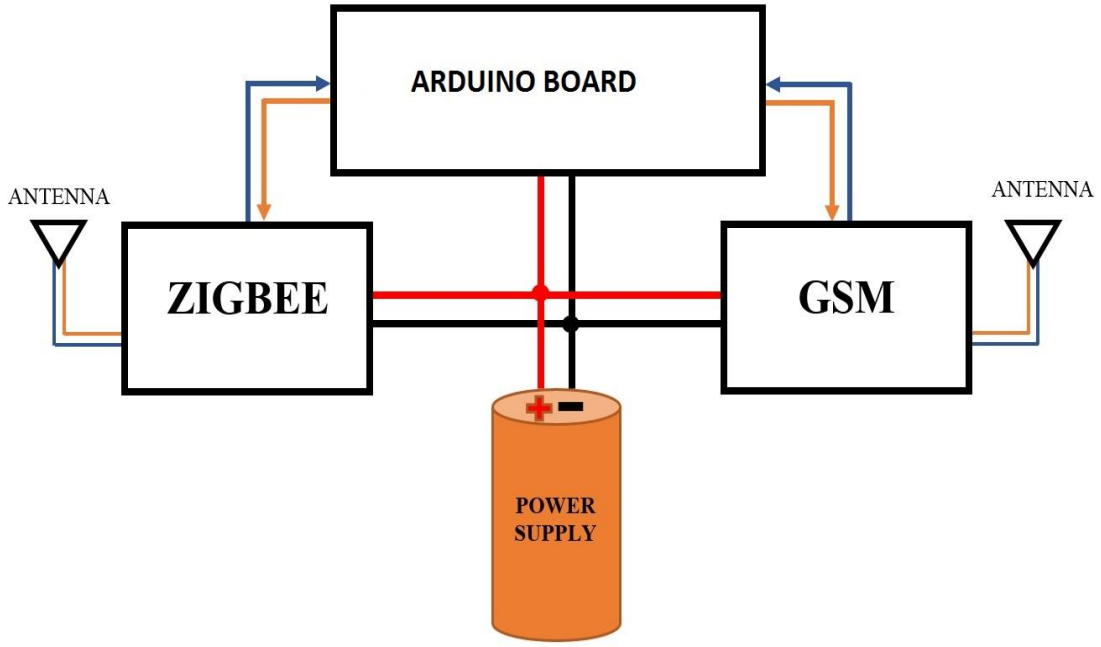


Figure 1.5 Block Diagram of the Switchover Unit

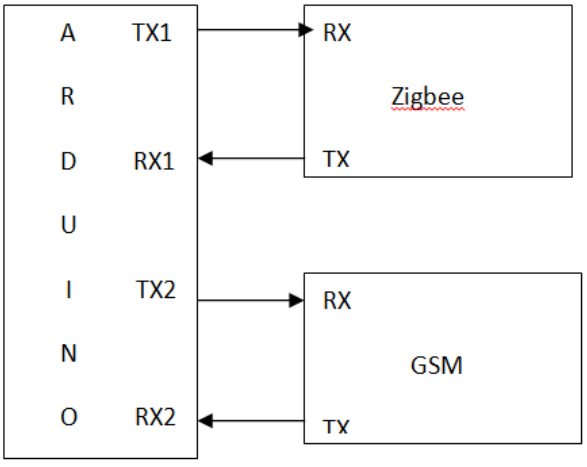


Figure 1.6 Diagram Showing the Communication among Different Modules of Switchover Unit

It consists of following parts

1. Zigbee module
2. Arduino board
3. GSM module
4. Power Supply

a. Zigbee module

Here the Zigbee module receives the data sent by the Zigbee transmitter module present in the Vehicle unit. The TX and RX pin of this module is connected to RX1 and TX1 of the Arduino board as shown in the figure no.. So the Zigbee receiver will give the received data to th Arduino board.

b. Arduino board

The Arduino board of the switchover module will receive the data from receiver Zigbee module and give it to the GSM module present in the switchover module. Here the TX2 and RX2 of the Arduino board is connected to the RX and TX pins of the GSM module.

c. GSM module

It does the same work as in Vehicle unit i.e. it receives the data from Arduino board and sends it to web server through GPRS gateway.

d. Power supply unit

It also does the same work as in Vehicle unit i.e. It supplies power to different modules. It supplies 5V for Arduino board and GSM module. It also supplies 3.3V for Zigbee module.

1.7.3. Web server

It receives the data from GSM module. The data can be sent directly to the Graphical information system. We can also store the data in the database of the web server and then the Graphical information system will retrieve the data by requesting the web server. Codes are written at the web server for extracting the actual information from the data sent by the GSM module. The GSM module should send the data according to the code written at the web server. If we want to track a number of vehicles in a particular area then we have to send the vehicle

number along with the latitude and longitude information in order to differentiate between them. The web server will store the data in a table as follows.

VEHICLE NO.	LATITUDE	LONGITUDE	RECEIVING TIME
Vehicle 1	Latitude 1	Longitude 1	Time 1
Vehicle 2	Latitude 2	Longitude 2	Time 2
Vehicle 3	Latitude 3	Longitude 3	Time 3
Vehicle 4	Latitude 4	Longitude 4	Time 4
. . .	. . .	. . .	. . .
Vehicle n	Latitude n	Longitude n	Time n

Table 1.1 web Server database

The above table will be repeated again and again as long as the web server will receive the data from the GSM modules. Other information can be stored in the web server database by increasing the number of columns in the above table.

1.7.4. Graphical information system

The graphical information system will display the location of the vehicles at a particular location. It consists of a computer in which the map of the area where we want to locate the vehicles is loaded. The computer must have internet connection to access the data stored in the web server. We can use some symbol to represent the vehicles in the map. We can directly give the extracted latitude and longitude values to the Google map and after that we can view the location of the vehicles on the Google map. If we want to use this system in a particular area only, then we can create the map of that area by using some programming language. We can number the symbols used for differentiating the vehicles.

1.8. Flowchart of the proposed solution

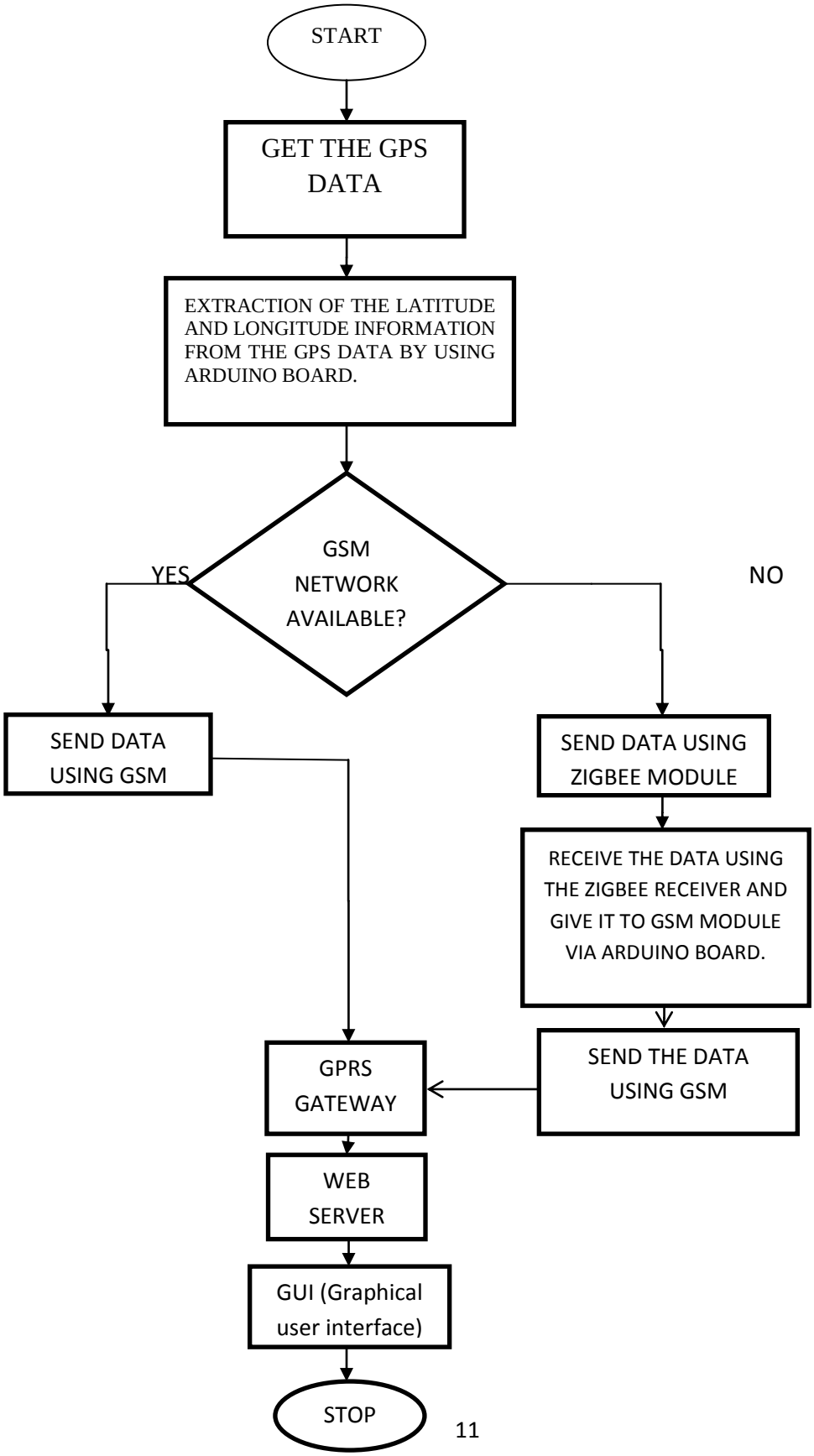


Figure 1.7 Flowchart of Proposed System

1.9. Structure of a mine after the implementation of the proposed idea

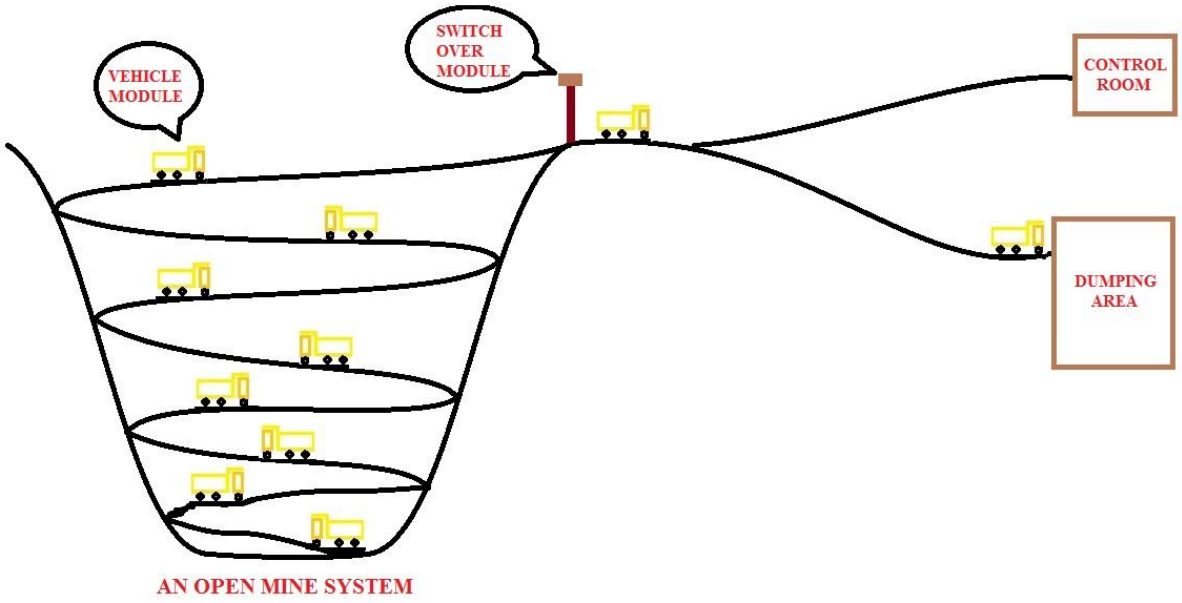


Figure 1.8 Structure of an Open Mine System after the Implementation of Proposed Idea

Figure 1.8 shows the idea has been implemented in an opencast mine. Here the switchover module is placed at the location where GSM network is available. Each vehicle moving inside the mine is having a vehicle unit. If GSM signal is available the vehicle unit will directly send the data to web server otherwise through switchover module.

2. DESCRIPTION OF THE INDIVIDUAL HARDWARE USED

2.1. GPS module

2.1.1. Basic concept

GPS is a system that gives the location information as well as time information. It gives the exact information only when at least four GPS satellites are visible to it. The GPS satellites are having clocks that are stable and are matched with the ground clocks. These satellites give their location and time information repeatedly. The GPS receiver receives this information and calculates its exact location and its time deviation from exact time. The GPS receiver calculates four quantities, out of these three are space coordinates and the last one is the time difference between the satellite time and the signal received time.

Every GPS satellite sends a signal repeatedly. This signal consists of a code called pseudorandom code and a message consisting of transmission time of the code and satellite position. From the arrival time and transmission time GPS receiver will calculate the space coordinates and the time deviation.

GPS data format

The GPS receiver gives the data in NMEA protocol. The GPS data consists of the position information as well as time information. It gives the latitude, longitude, MSL, time of data transmission etc. The GPS receiver sends GGA, GSA, RMC, VTG, GSV sentences of the NMEA standard.

$GPGGA,090161.123,0928.146,N,012361.163,E,2,09,0.1,445.4,M,62.1,M,,*64

$GPGSA,A,02,5,,09,15,,,,26,,,,,3.6,1.8,2.5*31

$GPGSV,1,5,07,09,30,654,35,03,89,135,23,65,24,124,14,36,12,768,18,*76

$GPVTG,078.9,T,078.6,M,078.5,N,011.6,K*34

$GPRMC,09031.000,A,0964.8974,N,08882.1313,E,022.68,084.89,214677,062.90,W*8D

Here the ‘$’ sign indicates the starting of NMEA sentence, next two letters indicate the type of device (GP for GPS) and next three letters indicates type of NMEA sentence.

2.1.2. Description of the module used

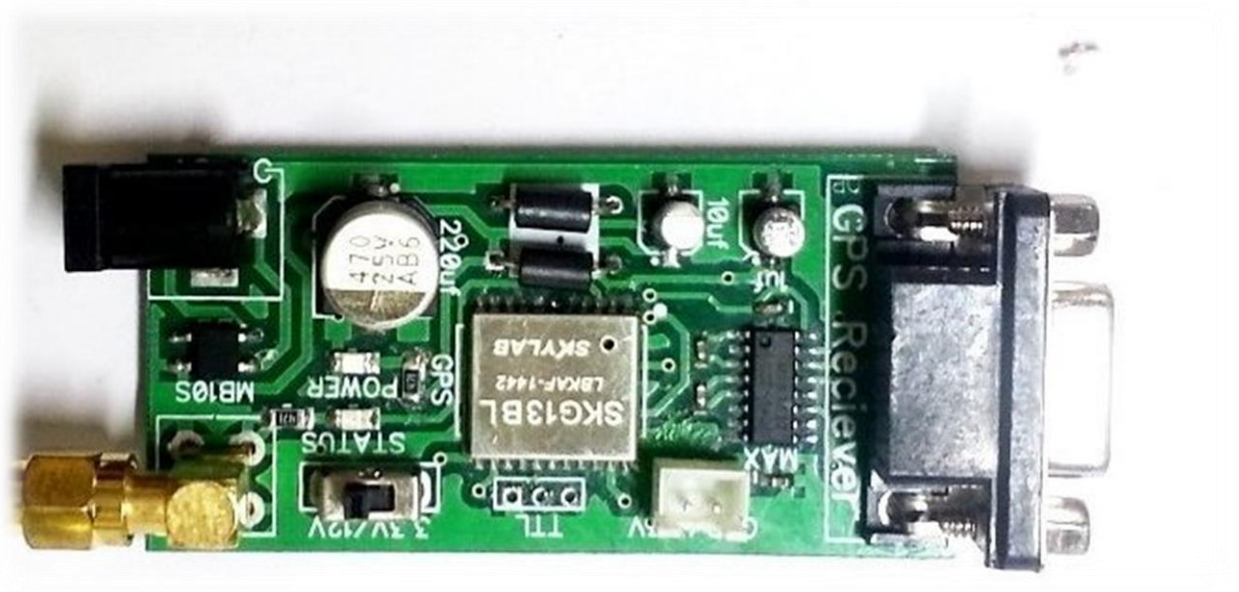


Figure 2.1 SKG13C GPS Module

Here the GPS module used is SKG13C GPS Module from Skylabs. It uses the SKG13BL GPS chip. It uses an external antenna to receive the signals from the satellite. An SMA connector is available for connecting the external antenna with the GPS module. It is having one RS-232 port for serial communication with the computer. The GPS data can be viewed in computer using hyper terminal software. It is also having two external pins TX and RX for communicating with other devices. The power can be supplied through a power jack or through two external pins name as Vcc and GND. The Vcc and GND pins are used if power is supplied through battery. This module can operate with 12v supply as well as 3.3v supply. A switch is there to indicate that at what power supply the module is operating. Two LEDs are there, one is power LED indicating availability of power and the other one is status LED indicating whether the GPS is locked or not(that is GPS is receiving valid data or not from the GPS satellites).

SKG13BL GPS chip

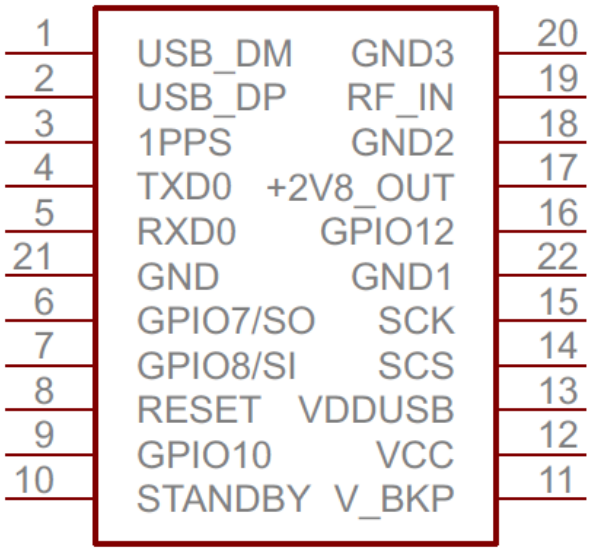


Figure 2.2 PIN DIAGRAM OF SKG13BL

The SKG13BL GPS chip consists of 22 pins. The detail pin description is shown in the following table.

PIN NO.	PIN NAME	DESCRIPTION
1	USB_DM	Used as I/O pin and left open if not used.
2	USB_DP	Used as I/O pin and left open if not used.
3	1PPS	Used for time measurement.
4	TXD0	It transmits the serial data to external devices.
5	RXD0	It receives the serial data from external devices.
6	GPIO7	Used as I/O pin.
7	GPIO8	Used as I/O pin.
8	RESET	Used to reset the module and its status is active low.

9	GPIO10	It indicates the existence of E2PROM.
10	STANDBY	Used as input pin.
11	V_BKP	It is connected to power supply or battery for backup.
12	VCC	Power supply is given through this pin.
13	VDDUSB	It is the USB power supply of 3.3v.
14	SCS	Used as I/O pin.
15	SCK	Used as I/O pin.
16	GPIO12	This is the general purpose I/O pin.
17	+2V8_OUT	It is a 2.8v power output and is used as antenna power.
18	GND2	Ground pin.
19	RF_IN	GPS receives the signals from satellite through this pin.
20	GND3	Ground pin.
21	GND	Ground pin.
22	GND1	Ground pin.

Table 2.1 PIN Description of GPS Chip

Interfaces configurations

Power supply

There are three power supply pins available in this GPS chip namely VCC, VDDUSB and V_BKP. The VCC pin is the pin through which power supply is provided to the chip. The input voltage to this pin ranges from 3v to 4.2v. The V_BKP pin is can be connected to a battery for backup in case of power failure. The typical value of the input voltage to the pins VDDUSB and V_BKP is 3.0v. The input current should be at least 100mA.

Reset

When an active low signal is applied to the RESET pin the module will automatically reset. If the input at the VCC pin goes below 2.7v the module will go to reset state. If we do not want to use reset then RESET pin can be left open.

Antenna

The SKG13C module supports both the antenna (that is both passive and active). The external antenna is connected to the RF_IN pin through a SMA connector. The antenna gain should be less than 23dB, noise figure should be less than 1.4dB and the output impedance should be about 50ohm.

Vcc_out

The external active antenna will take power from this pin. It will provide an output voltage of 2.8v.

UART ports

This is used for serial communication. The data format is “B , NP , 8 , 1 ”. Where

B→ Baud Rate

NP→ parity bit is not sent

8→ These are the data bits

1→ indicates one stop bit

This is the only data format supported. To increase the stability of the data the pins TX and RX are connected to pull up resistors of 10 kohm.

GPIOs

This pin is used to indicate the status of the GPS that is whether the GPS is locked or not. An LED along with a 220ohm series resistor is used to indicate this status.

2.1.3. As a part of the product

This module is used in as part of the vehicle unit. It gives the location information of the vehicles that are moving in the mine. It gives many information about the position of the vehicles as well as time of transmission and reception of the message. These information can be viewed

on computer by using various software. The software used here is Hyperterminal software. The GPS data displayed on computer using Hyperterminal software is shown below.

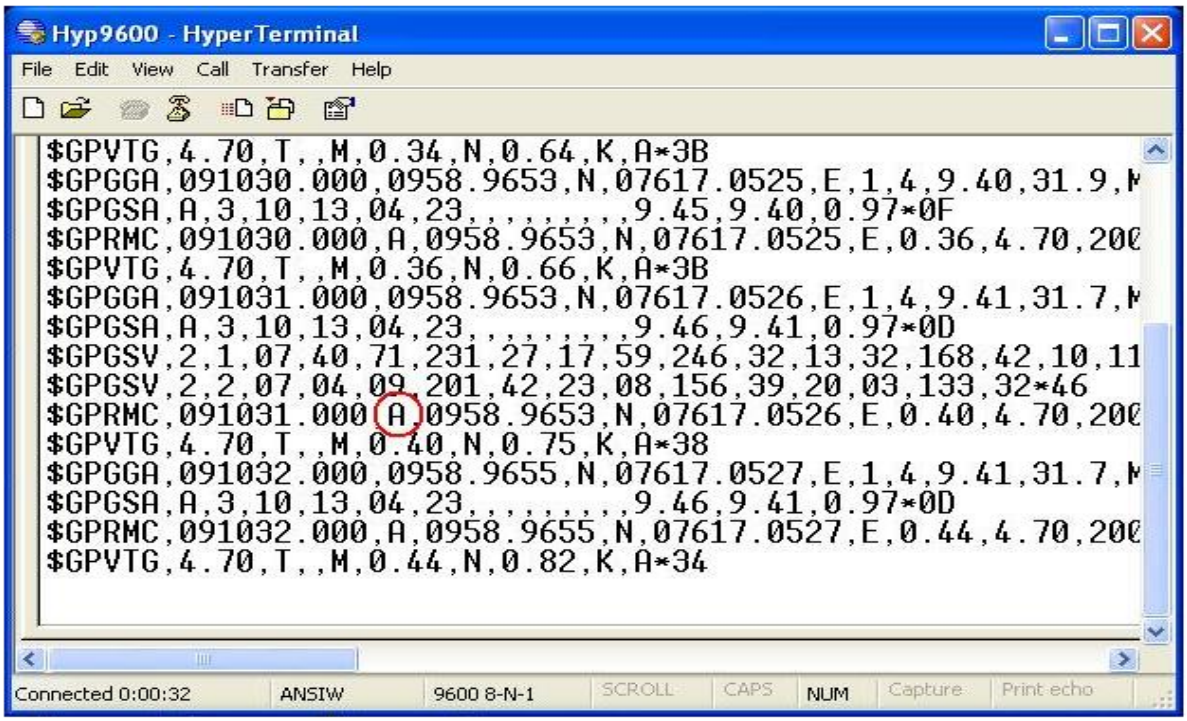


Figure 2.3 Displaying GPS data on Hyperterminal Software

The GPS receiver is giving five types of NMEA sentences but here we are using GPRMC sentence only.

Description of GPRMC sentence

$GPRMC,173554,A,4658.089,N,1855.234,E,39.89,082.12,231194,089.12,W*6B

DATA	DESCRIPTION
$	Start of the NMEA sentence.
GP	Device name i.e. GPS
RMC	RMC sentence (Recommended minimum).
173554	It is taken at 17:35:54.

A	Indicates whether the data is valid or not. A→Valid, V→ Invalid.
4658.089,N	Latitude 46 degree 58.089’ towards north.
1855.234,E	Longitude 18 degree 55.234’ towards east.
39.89	Ground speed
082.12	Track angle
231194	Date 23.11.1994
089.12,w	Magnetic variation
6B	Checksum, which is the Ex-OR of all the data.

Table 2.2 GPRMC Sentence Description

To locate the vehicles in the map we need to extract the latitude and longitude values from the GPRMC sentence. To extract this information the GPS module is Interface with Arduino as shown below.

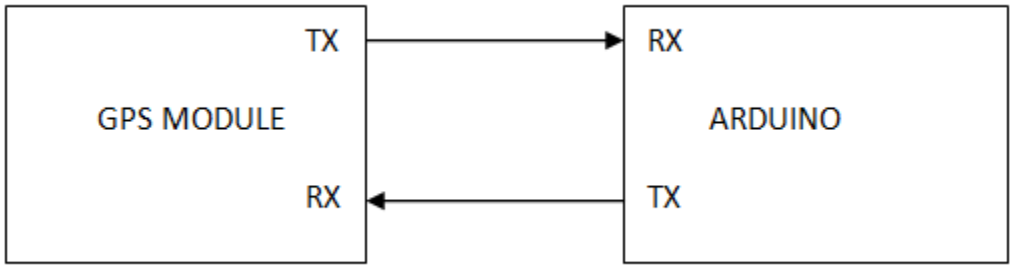


Figure 2.4 Communication between Arduino Board and GSM Module

Here the TX pin of the GPS module is connected to the RX pin of the Arduino and vice versa for serial communication. Here a special code has been written and uploaded to Arduino board using Arduino IDE software. This code will extract the latitude and longitude value and display it on the serial monitor of the Arduino IDE software. The latitude and longitude will be displayed only when the GPS is locked i.e. only when the green LED is ON. Following figure shows the latitude and longitude value extracted by the Arduino.

Figure 2.5 Latitude and Longitude Extracted Using Arduino

2.2. Arduino board

2.2.1. Basic concept

It is a board consisting of microcontroller and several supportive components for easier programming. It provides a number of analog and digital input/output pins through which a lot of device can be interfaced with it.

Because of its more no of I/O pins it works as an intermediate for the communication between various devices and thus complex work can also be done easily. It is having several UART ports for serial communication with other peripheral devices. Arduino provides a very good programming platform which supports programming languages like C and C++. The Arduino IDE software is used to write the program and to upload it on the Arduino board and also it is having a serial monitor, which display the serial data coming from the peripheral device interfaced with the Arduino board. There are several Arduino libraries defined, because of which Arduino programming is somewhat easy compared to programming the microcontroller separately. The libraries are the files written using C language. The Arduino program has two

important parts, one is Setup function and the other one is loop function. Within the Setup function the baud rates of the serial ports and serial monitor are set. The codes which need to be repeated are written inside the loop function. The codes inside the setup function is executed only once when the device is turned on but the codes inside the loop function will be executed repeatedly. The variables, constants, parameters are declared above the setup function. The libraries are included by using #include statement and the constants are defined by using #define statement. The usage of Arduino libraries makes the program simpler and shorter.

2.2.2. Description of the module used

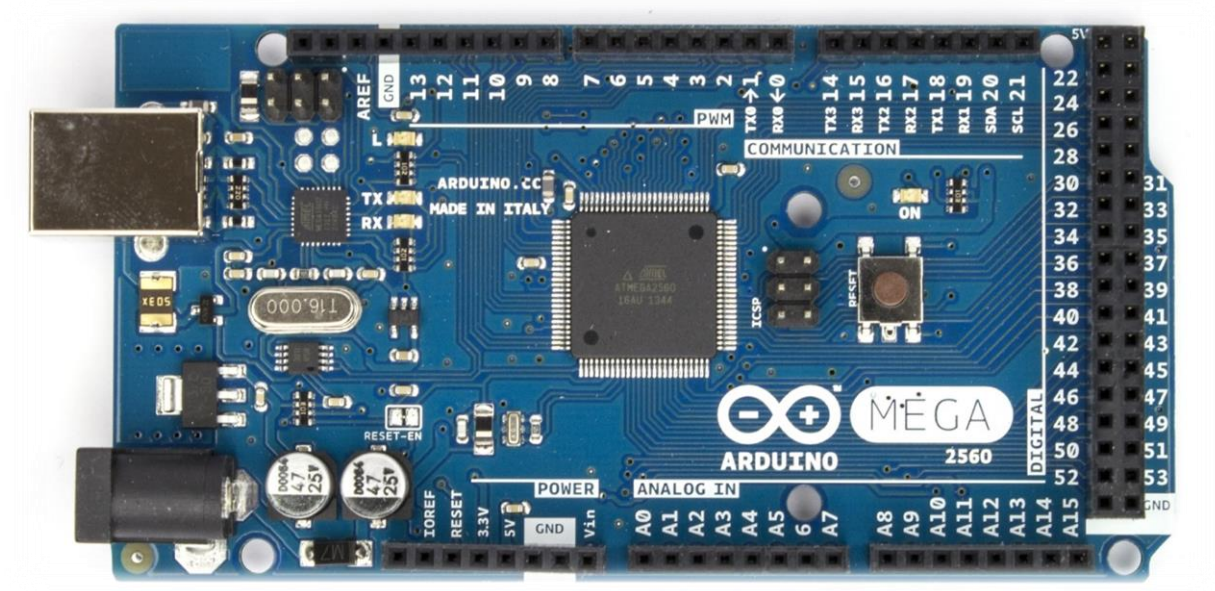


Figure 2.6 Arduino Mega 2560

The Arduino board used here is Arduino Mega 2560. It consists of the ATmega2560 microcontroller chip. It is having a number of I/O pins (54 numbers) which are digital in nature i.e. inputs applied to them are digital signals and outputs obtained from them are also digital. There are 16 input pins which can take analog signals as input. It consists of four pair of serial communication ports through which different peripheral devices can communicate with the ATmega2560 microcontroller. It is having all the supportive components required for the microcontroller to function properly. A crystal oscillator of 16MHz is present on this board. A power jack is provided to supply the power through adapter. To communicate with the computer

a USB connection is also present in this board. An ICSP header is present to directly program the microcontroller without the help of Arduino IDE software. It also consists of a RESET button to reset the microcontroller. The ATmega16U2 chip present on the board is programmed such that it behaves like a USB to serial converter. So Arduino Mega 2560 board don't need any FTDI driver chip. This board is compatible with various devices so it is easier to communicate with them and also these devices take power from the Arduino board so extra power supply is not required.

Power

This board can be powered through USB port or through external power supply. If the power is supplied externally, then it can be given through power jack by using adapter or through battery. The input voltage to this board ranges from 7V to 12V.

NAME	TYPE	DESCRIPTION
VIN	Input	When power is supplied through battery this pin is used.
5V	Output	It gives an output voltage of 5V. Other peripheral devices can take power from this pin. If the power supplied to The Arduino board is less than 7V then this pin will give a voltage less than 5v.
3V3	Output	It gives an output voltage of 3.3V and an output current of 50mA.
GND	Ground	It is the ground pin.
IOREF	Output	It gives the voltage at which the microcontroller is operating.

Table 2.3 Power Pin Header of Arduino Mega 2560

Memory

It has 256KB of flash memory to store the program. It is also having 8KB of SRAM and 4KB of E2PROM. Out of 256KB flash memory bootloader uses 8KB.

Inputs and Outputs

The digital pins can be used as either input or output by using the functions PinMode, digitalWrite and digitalRead. Each of these 54 pins can take a maximum of 40mA and operate at 5V. Some pins have special functions, which are described in the following table.

TYPE	PIN No.	DESCRIPTION
Serial 0	0(RX),1(TX)	Used for serial communication.
Serial 1	19(RX),18(TX)	Used for serial communication.
Serial 2	17(RX),16(TX)	Used for serial communication.
Serial 3	15(RX),14(TX)	Used for serial communication.
Interrupt 0	2	Used as external interrupt.
Interrupt 1	3	Used as external interrupt.
Interrupt 2	21	Used as external interrupt.
Interrupt 3	20	Used as external interrupt.
Interrupt 4	19	Used as external interrupt.
Interrupt 5	18	Used as external interrupt.
MISO	50	Supports the SPI communication.
MOSI	51	Supports the SPI communication.
SCK	52	Supports the SPI communication.
SS	53	Supports the SPI communication.
PWM	2 to 13, 44 to 46	Gives PWM Output.
SDA	20	It supports TWI communication.
SCL	21	It supports TWI communication.
LED	13	It is connected to pin 13 and blinks when the pin is at high state

Table 2.4 Pins of Arduino Mega 2560 with Special functions

There are 16 analog pins which give 10 bits resolution. These pins measure up to 5V but this can be increased by using AREF pin.

Communication

The Arduino Mega 2560 can communicate with computer, other microcontroller and peripheral devices. It provides four UARTs for serial communication. The Arduino IDE software is having a serial monitor which allows to send text from and to the board. There are TX and RX LEDSs which will blink during the serial communication. Any digital pin can be used for serial communication by using the SoftwareSerial library.

Programming

The Arduino mega 2560 can be programmed by using the Arduino IDE software or can be programmed by using ICSP header using Arduino ISP. The bootloader present in it allows to upload new programs without any need of an external programmer. The program is written in the Arduino IDE window, then it is verified and finally it is uploaded. There are several libraries and predefined functions present so programming is easier compared to normal programming. Various devices like GSM, Zigbee, GPS are interfaced easily and communicate with it because of its libraries.

USB Over current protection

It is having one resettable polyfuse which protects the USB ports of the computer from over current.

Shield compatibility

It is compatible with various devices like GPS shield, GSM Shield etc. So interfacing with these devices is very easy.

2.2.3. As a part of the product

It works like a heart of the system. It is used both in vehicle unit and switchover unit. It is interfaced with GPS, GSM and Zigbee in vehicle unit and interfaced with GSM and Zigbee in switchover module.

a. Usage in vehicle unit

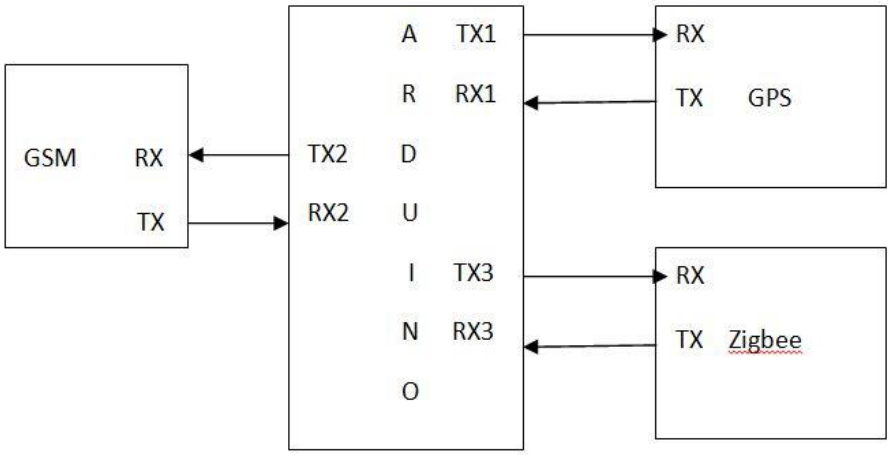


Figure 2.7 Use of Arduino Board in Vehicle Unit

Here TX1 and RX1 serial ports of Arduino board is connected to RX and TX of the GPS module respectively. Similarly, TX2 and RX2 are connected to the RX and TX pin of the GSM module and TX3, RX3 are connected to RX, TX of the Zigbee module. The Arduino board does the following functions in the vehicle unit.

- It receives the data from GPS module through its serial ports.
- Extracts the latitude and longitude information from the raw data received from the GPS module.
- It checks the availability of the GSM network.
- It gives the latitude and longitude values extracted from the GPS raw data to the GSM module, If GSM network is available.
- It gives the data to Zigbee module, If GSM network is not available.

These individual functions are performed by different code segments and these code segments are written and uploaded to Arduino by the help of Arduino IDE software. Here all the code segments are combined into a program and uploaded to the Arduino so that all the functions are

performed in a systematic way. We can see the responses of the GSM module and also the latitude and longitude value on the serial monitor of the Arduino IDE software.

b. Usage in the switchover Unit

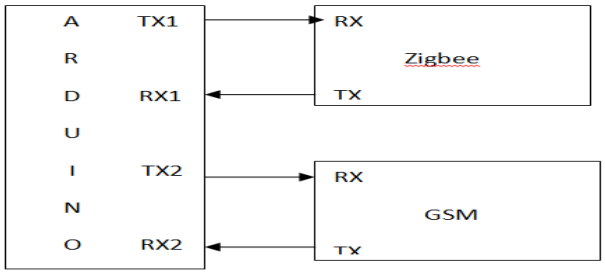


Figure 2.8 Use of Arduino Board in Switchover Unit

Here one of the serial port of the Arduino Mega 2560 is connected to the serial port of the Zigbee module and another one is connected to that of the GSM module. It does the following functions in the switchover unit.

- It receives the latitude and longitude values from the receiver Zigbee.
- After receivinf the data from Zigbee it gives it to the GSM module present inside the switchover unit.

Similar to vehicle unit here also a program is written in the Arduino IDE software window and uploaded it to the Arduino so that all the functions are performed in a systematic manner.

2.3. Zigbee

2.3.1. Basic concept

It is a specification used for high level communication protocols. It is based on IEEE 802.15.4 standard. It is particularly used for short range communications. Basically it gives a range up to 1 mile if sufficient power is supplied to it. There are several Zigbees developed now a days which can transmit data in kilometre range also. It used in the applications which require long battery life and secure networking. These devices consume less power and have low

latency. It operates in ISM radio band: 784 MHz to 2.4 GHz. Its data rate varies from 20Kbps to 250 Kbps.

Zigbee Networking

If we want to transmit a data using Zigbee and the destination is far from the source(i.e. not in the range of a single Zigbee) then we have to use zigbee networking. In Zigbee networking we can interconnect the Zigbee devices with each other such that they will transmit the data without any break.

1. Types of Zigbee devices

Based on the functionality the Zigbee devices in the Zigbee network they are classified into three types as follows.

a. Coordinator

In every Zigbee network there must be one and only coordinator. A Zigbee device functioning as a coordinator has the following tasks.

- It will select the appropriate channel for the data transmission.
- It will select the PAN ID (i.e. the personal area network ID) to start the network.
- IT allows the routers and the terminal devices to join the network.
- It also helps in routing the data.
- It can't go in sleep mode. It must be active always.
- These devices can only transmit and route the data but can't receive.

b. Router

These are the intermediate devices and helps in routing the data to the destination. These are having the following characteristics.

- These devices can transmit the data, can receive the data and can route the data.
- Before start functioning it must have to join the network.
- After joining the Zigbee network it routes the data as well as allows the terminal devices to join the network.
- These devices also can't go into sleep mode.

c. **End devices**

These devices are the destination devices. These devices are having the following characteristics.

- These devices can transmit and receive the data but, it can't route.
- It can transmit and receive the data only from its parent devices.
- Before being active the data it must has to join the Zigbee network.
- It can't allow a new device to join the network.
- It can go into sleep mode.

2. Zigbee network topologies

Zigbee network uses three types of topologies which are as follows

a. Star topology

Here, one end device can send the message to another end device through the coordinator only. Router node is not required here. The next hop address is nothing but the address of the coordinator and final destination address is the address of the end device where the message is to be sent.

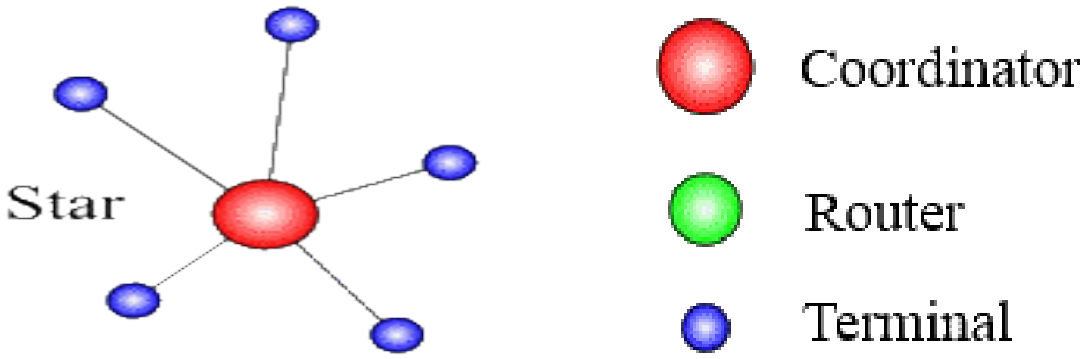


Figure 2.9 Star Topology

b. Cluster tree topology

Here, the data to be sent is routed up the tree until it reaches a node which will route it down the tree to the destination device. Here the next hop address is nothing but the address of the parent of the transmitting device. The parent node will send the data to the next relevant node and this procedure will be repeated until the destination is reached.

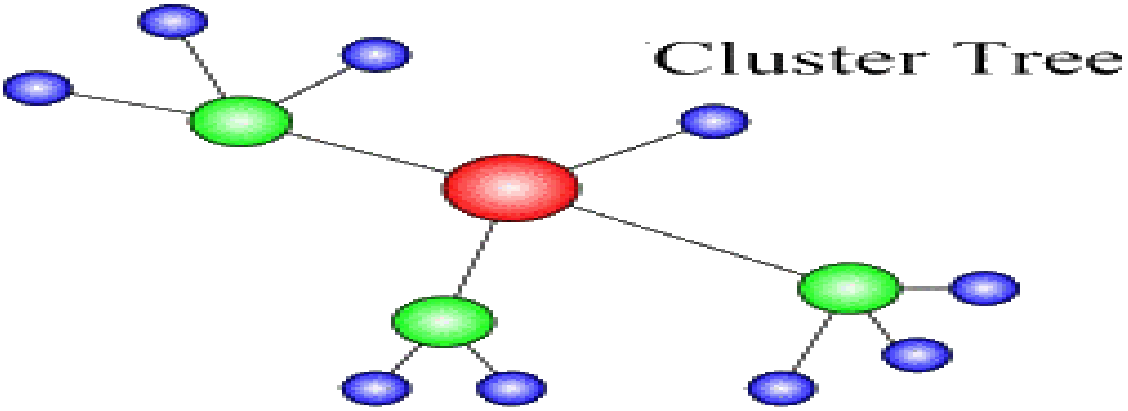


Figure 2.10 Tree Topology

c. Mesh topology

It is the most effective among all the topologies. Here the data transmission is possible in various path. Here a path with higher signal strength and shorter distance is always selected. The message propagation path depends on the whether the target node is in the range or not. If the destination node is in the range, then final destination address is used. If the destination node is not in the range then next hop address is used. This procedure is repeated until the destination node is reached.

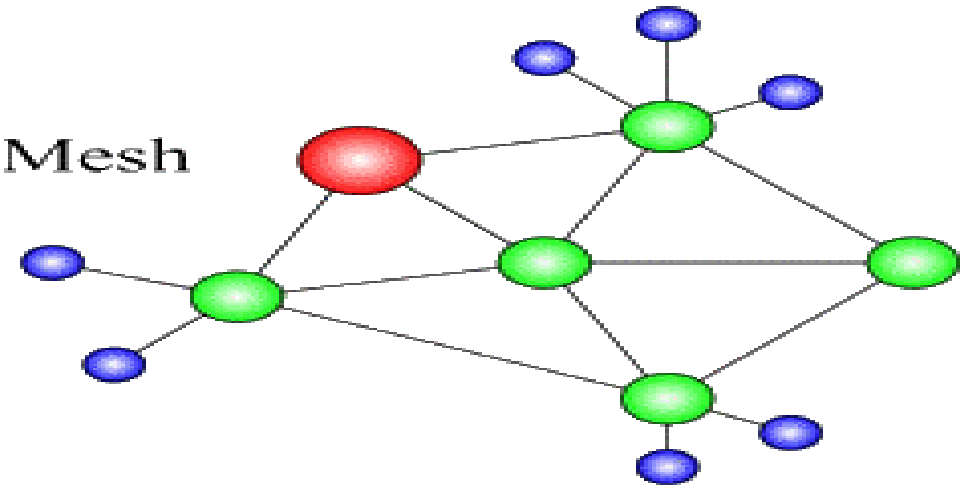


Figure 2.11 Mesh Topology

2.3.2. Description of the module used

The zigbee used here is XBee pro 63mw RPSMA. XBee is the name given to Zigbee by Digikey. It is a series 2B module and is compatible with series 1 Zigbee modules.

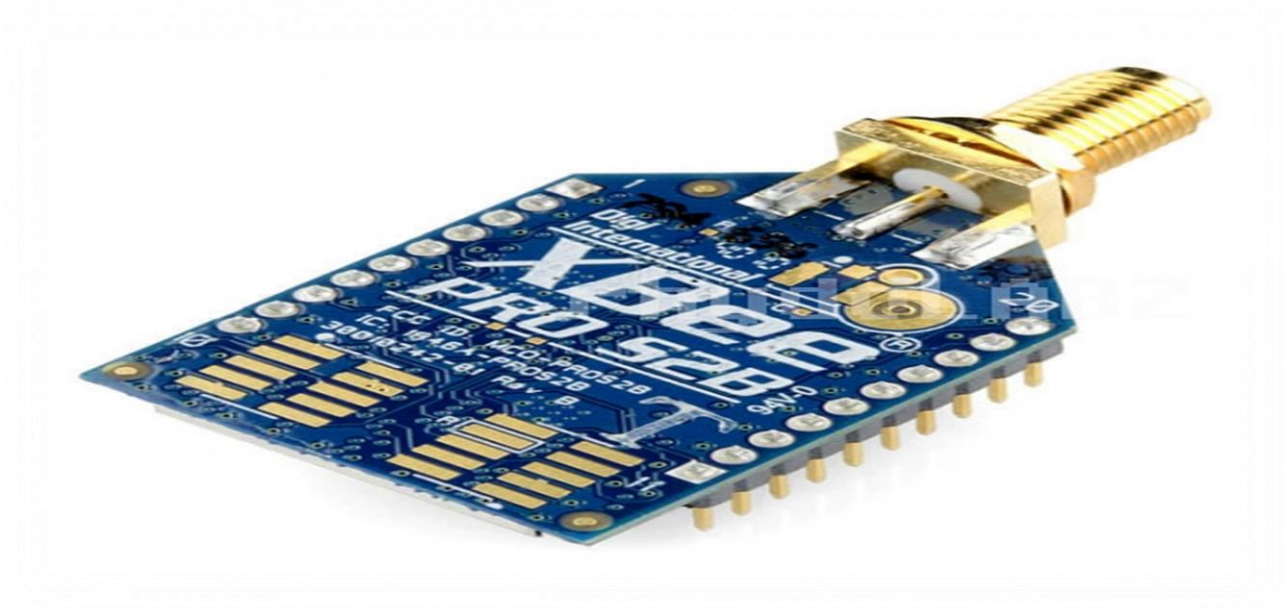


Figure 2.12 XBee Pro 63mW RPSMA - Series 2B (ZigBee Mesh)

Features

- It takes an input voltage of 3.3V and a current of 295mA.
- The maximum data rate of this module is 250 Kbps.
- It provides an output power of 63mW.
- The maximum range is about 1 mile.
- It is having one RPSMA connector.
- It is having 8 input/output pins which are digital in nature.
- It requires an external antenna.
- It supports both AT and API commands.

Antenna used

The external antenna used here is a 2.4 GHz duck antenna with RPSMA connector(male). It is having an impedance of 50ohm, and a gain of 2.2 dBi.

Figure 2.13 Zigbee Antenna

2.3.3. As a part of the product

The use of the Xbee in this product makes it different from other vehicle tracking systems. It is very useful when the GSM network is not available at any place of the mine. It is used for sending the latitude and longitude information Whenever GSM network is not accessible.

Configuration

Before using the XBee devices they need to be configured. Configuring a Zigbee means fixing the PAN ID, Setting the source address and destination address, choosing the type of

command set(i.e. AT or API), defining the baud rate, seting the parity bit etc. The Configuration is done by using the XCTU software As follows.

1. First the XCTU software is loaded into a computer.
2. Then firmware update is performed.
3. Xbee module is interfaced with a USB to serial converter and then the converter is connected to the computer by the help of a USB cable as shown below.

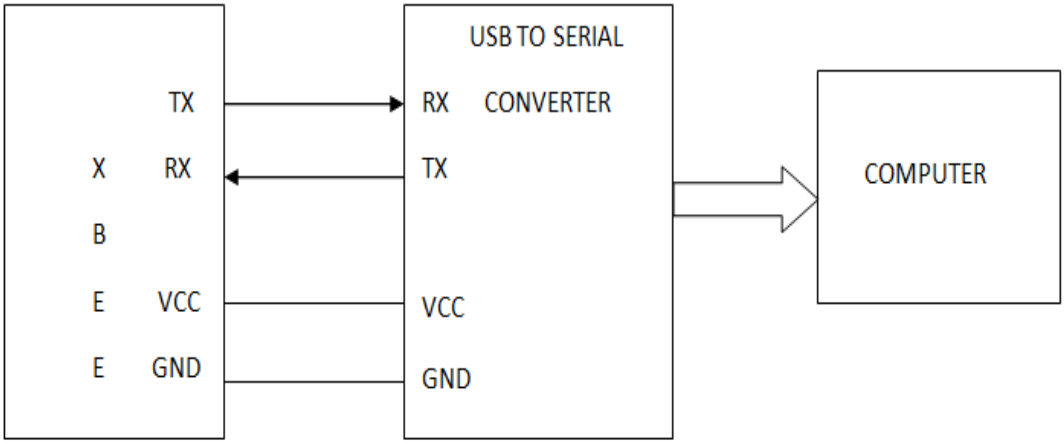


Figure 2.14 Communicating Zigbee with Computer

Here both the modules will take the power from the computer through USB cable.

4. Now open the XCTU software, then select the appropriate COM port and set the parity bit baud rate etc.
5. Now the software will read the device type, firmware version and the serial number of the device.
6. After that the following window will open.

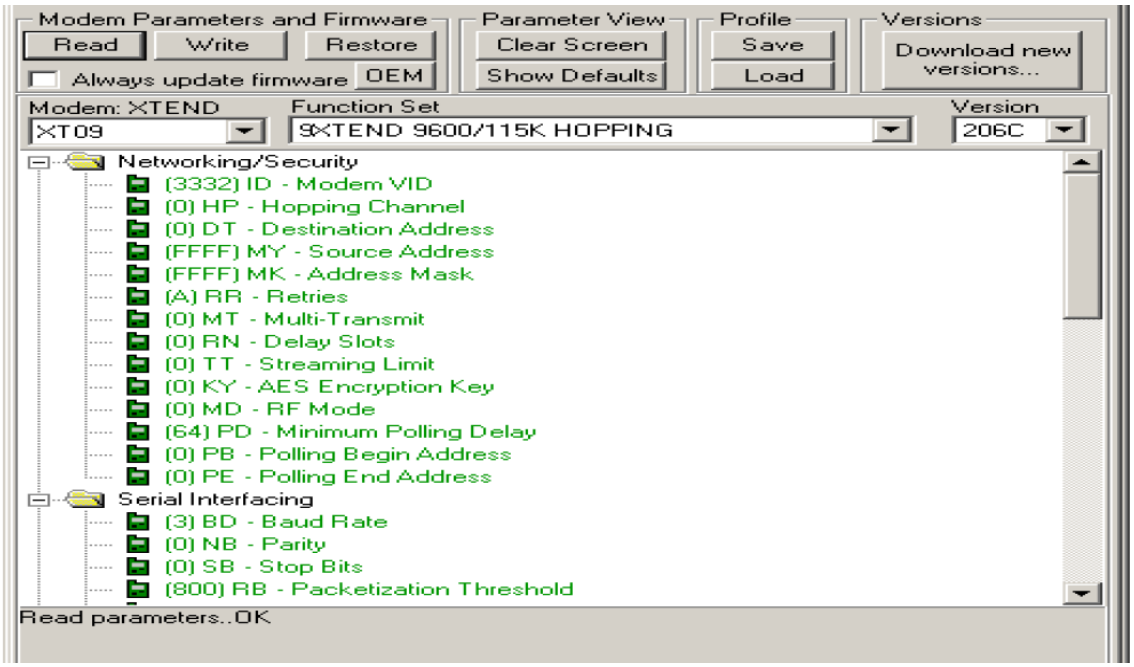


Figure 2.15 Zigbee Configuration using XCTU Software

7. The function set is mentioned now. For transmitter Zigbee it is set to coordinator AT and for receiver Zigbee it is set to Zigbee router AT.
8. The PAN ID is set to a particular value. If any Zigbee device wants to join this Zigbee network then it must have the PAN ID same as the coordinator PAN ID.
9. For the transmitter Zigbee the node identifier is set as coordinator and for receiver zigbee it is set as end device.
10. The destination address of the coordinator is set to a value same as source address/serial number of receiver and vice versa.

Now the zigbees are configured and communicate with each other. The communication between these devices can be seen on the terminal window of the XCTU software. Here "Hello XBee Network: is sent from the transmitter and received by the receiver Zigbee .

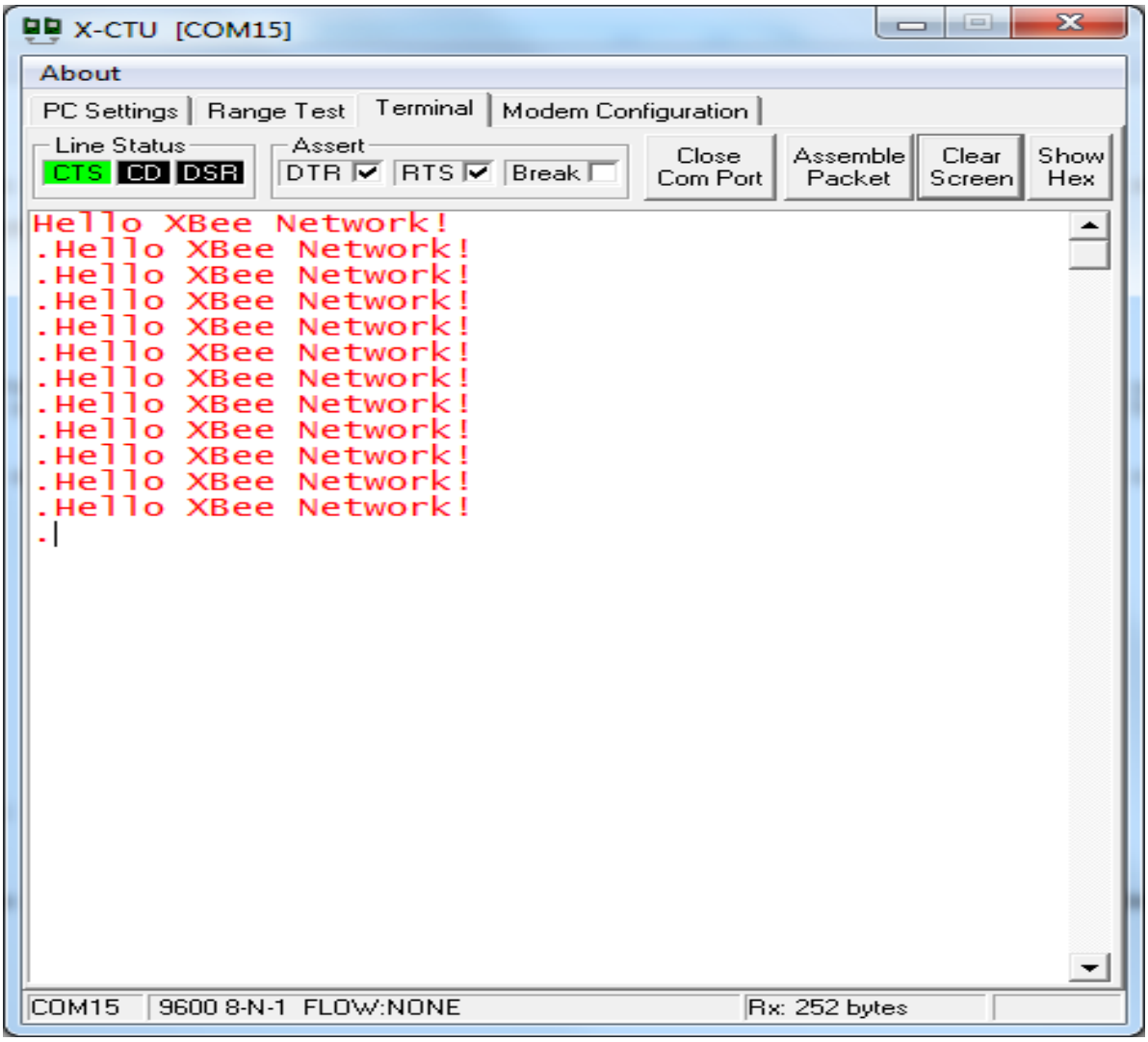


Figure 2.16 Received data using Zigbee

a. Usage in the vehicle unit

The Zigbee transmitter is used in the vehicle unit. Its interfacing with various components of the vehicle unit as shown in the figure no.(). In vehicle module the Zigbee transmitter module takes the extracted data from the Arduino board and sende it to the receiver Zigbee module through the external antenna.

b. Usage in the switchover unit

The Zigbee receiver module is placed in the switchover unit. Its interfacing with the other components of switchover module is shown in the figure no.(). The Zigbee receiver receives the data sent by the transmitter Zigbee through the external antenna and give it to the Arduino board.

2.4. GSM module

2.4.1. Basic concept

It is a standard developed to describe the protocols for the 2G cellular networks used by the mobile phones. It is a cellular network that means the mobile phones are connected to this network by searching the cells. The cell size in a GSM network can be macro, micro, pico fempto and umbrella cells. The 2G GSM network can operate at 900 or 1800 MHz frequency range.

2.4.2. Description of the module used

Figure 2.17 GSM/GPRS TTL UART modem-SIM900

Features

The module used here is GSM/GPRS TTL UART modem-SIM900. It can operate in frequencies 850MHz, 900MHz, 1800MHz, 1900MHz. It allows us to connect the 5V or 3.3V microcontrollers without any conversion IC. By the help of AT commands we can change its baud rate from 9600 to 115200. This modem is having TCP/IP stack which allow us to connect with internet via GPRS. It is used in many applications such as SMS sending, voice transfer, data transfer etc. Using this modem we can attend the incoming calls, and can connect to the internet.

It is having one SMA connector through which an external antenna is connected to the modem for sending and receiving the data. A SIM card holder is present where the SIM card is placed. Using this SIM card data can be sent to the internet, SMS can be sent to another SIM card and many things can be done. Three LEDs are there, Out of which one is indicating Network status(i.e the availability of the GSM network corresponding to the SIM card used in the modem) and other two are TX and RX LEDs indicating serial data transmission. It is having TCP/IP stack so it supports the the data transfer to internet via GPRS Gateway.

The power can be supplied through the VCC and the ground pin available in the modem. If we want to supply the power through battery then we have to connect the VCC pin with the positive terminal and GND pin to the negative terminal of the battery. We can supply the power from the computer by connecting one USB to serial converter in between GSM module and the computer.

It is having four pins TX, RX, V_Interface and GND to interface this module with other modules. If the controller to be interfaced operates at TTL 5V logic level then we have to give a voltage of 5V to the V_Interface pin. If the controller to be interfaced operates at TTL 3.3V logic level then we have to apply a voltage of 3.3V to V_Interface pin of the module.

Pin details

This module consists of five pin header. Each of these pin header has a specific function. The following table describes the functions of each pin of all the pin headers.

Pin Header Name	Pin Name	Input/Output	Description
DEBUG	1.GND	Ground pin	It is the ground pin.
	2.RXD DBG	Input	It is a receiver pin used for the firmware upgradation and debugging purpose.
	3.TXD DBG	Output	It is a transmitter pin. It is also used for firmware upgradation and debugging purpose.
	4.PWRKEY	Input	It is the power key used for firmware upgradation and when the GSM modem is upgrading the firmware it should be connected to the ground.
AUDIO	1.SPEAK	Output	It is the audio output.
	2.GND	Ground	It is the ground pin.
	3.MIC	Input	It is the audio input.
POWER	1.VIN	Input	It is the pin through which power is supplied to the module. The input voltage ranges from 4.5V to 12V.
	2.GND	Ground	It is the ground pin.
8PIN RMC CONNECTOR	1.NRESET	Input	It is the active low reset input.
	2.RTS	Input	It is the request to send pin.
	3.CTS	Output	It is the clear to send pin.
	4.PWRKEY	Input	It is the power key used for firmware upgradation and when the GSM modem is upgrading the firmware it should be connected to the ground.
	5.NETLIGHT	Output	It gives the network status. It gives an output 1 if the network is available otherwise an output 0.

	6.STATUS	Output	It gives the power status.
	7.RI	Output	It is the ring indicator pin.
	8.DTR	Input	It indicates the data terminal is ready or not.
INTERFACE	1.V_INTERFACE	Input	It is the voltage applied for on board voltage level conversion. If the controller to be interfaced operates at TTL 5V logic level then we have to give a voltage of 5V to this pin. If the controller to be interfaced operates at TTL 3.3V logic level then we have to apply a voltage of 3.3V to this pin.
	2.TXD	Output	It is used for data transmission in serial communication.
	3.RXD	Input	It receives the data from the interfaced module.
	4.GND	Ground	It is the ground pin.

Table 2.5 Pin Details of GSM/GPRS TTL UART modem-SIM900

AT Commands

The module responds to AT commands. We can communicate with the SIM900 chip with the AT commands only. Using these AT commands we can send SMS to another module, can establish TCP connection, can establish UDP connection, can attain an incoming call and many more functions can be performed. These AT commands can be given to the module by using a hyperterminal software or we can give it through Arduino programming. The response of the GSM module can be seen by using the Hyperteminal software or on the serial monitor of the Arduino IDE software. The basic syntax of the AT commands is

"AT<x><n>" or "AT&<x><n>"

Where, AT is the prefix written before every command. <x> is the command and <n> is the argument for that command.

TCP/IP Application

Structure

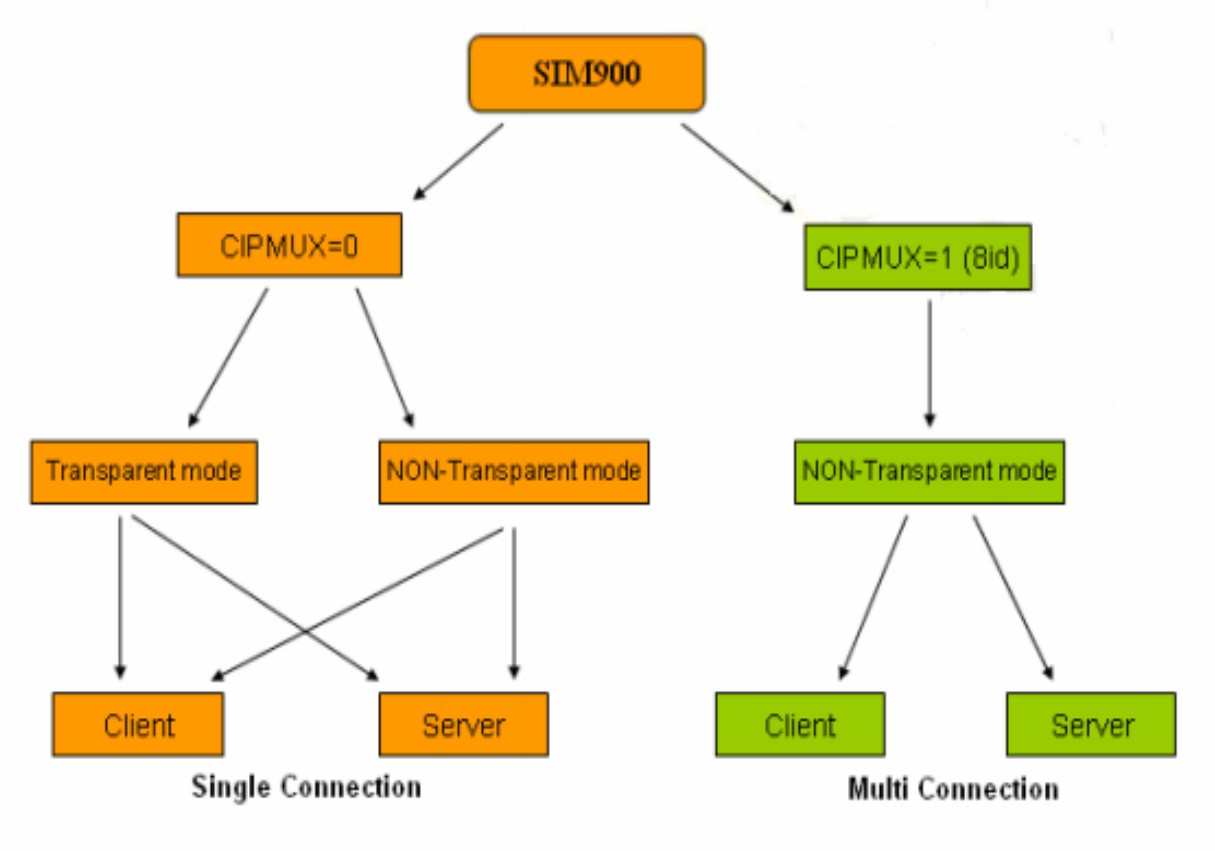


Figure 2.18 TCP/IP Structure

TCP/IP Structure of SIM900

For TCP/IP applications there are two modes of connection available in SIM900. These are

- Single connection
- Multi connection

AT+CIPMUX=<n> command is used for TCP/IP mode selection. For single connection ‘n’ value is 0 and for multi connection ‘n’ value is 1.

1. Single Connection

This is the default mode of SIM900. In this mode SIM900 can be used as TCP server or TCP client. SIM900 supports both transparent and non-transparent mode for single connection.

a. Non-transparent mode

The AT command for selecting TCP/IP application mode is AT+CIPMODE<n>. n=0, For non-transparent mode and it is the default mode. Under this application mode there are three working modes. These are

i. TCP client

Here the SIM900 will behave as a client. To establish a connection between the SIM900 and a server, we have to use the AT commands. The AT command used to establish the connection is “AT+CIPSTART=”TCP”.” IP address of the server”,” Port number of the server””. After the connection is established the SIM900 can send the data to the server.

ii. UDP client

It is similar to TCP client connection establishment. Here the At command used is is “AT+CIPSTART=”UDP”.” IP address of the server”,” Port number of the server”. After sending the data the GSM module give a response “SEND OK”. In TCP client connection it means the data has been received at the server’s port but, in UDP client connection it is not confirmed that data has been reached at the server’s port.

iii. TCP server

The command used for making SIM900 a server is AT+CIPSERVER=1,”<port>”. After that the SIM900 can allow a client to connect with it. Now it can receive data from the client.

Before establishing any of the above connections the module should be connected to GPRS network.

b. Transparent mode

This mode provides a special data mode for receiving and sending the data. After the connection is established in transparent mode the module automatically goes into data mode. All the data received from the serial port is treated as data packets and are transferred later. Similarly, all the data received from the remote side is directly sent to the serial port. All the At commands are not available in the transparent mode. To use the AT commands the module has to be switched from data mode to command mode.

2. Multi Connection

In multi connection SIM900 only supports non-transparent mode. Here also SIM900 can work as

a. TCP client
b. UDP client
c. TCP server

i. As client

As a client, it can establish eight connections to remote server for both TCP and UDP. After the successful connections data can be sent to the server.

ii. As server

As a server, it allows the clients to connect in and also at the same time it establishes connections to upper remote servers.

2.4.3. As a part of the product

a. **Usage in the Vehicle Unit**

The connections between and other components of the Vehicle unit is shown in the figure no. The GSM module is used for data transmission. Here it takes the data from Arduino and sends it to the web server. For sending the data to a web server the GSM module is used. For this first we have to establish a TCP connection with the web server to whom we want to send the data. The connection with the web server is done by using AT commands. The AT commands

are provided through Arduino. The interfacing between GSM module and Arduino board is shown below.

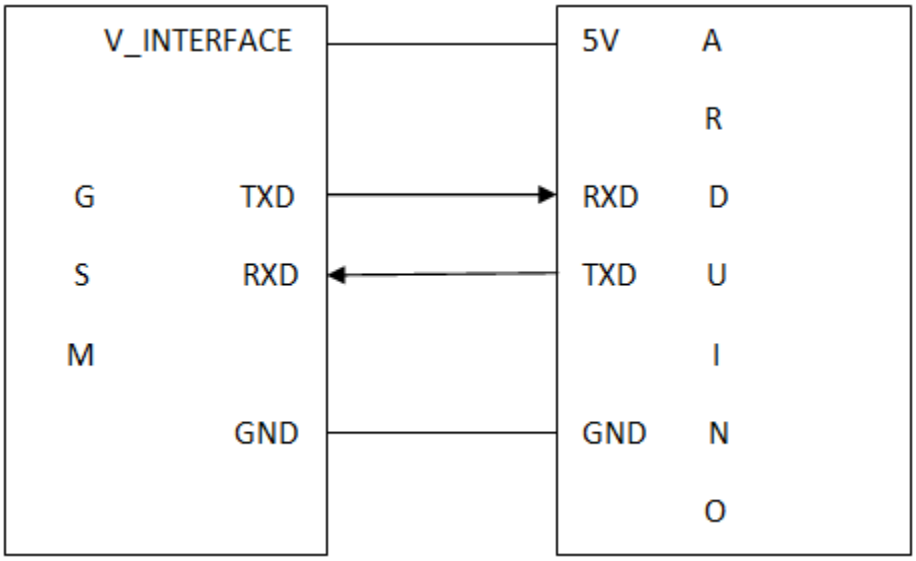


Figure 2.19 GSM and Arduino Interfacing

Here the 5V output of Arduino is connected to the V_INTERFACE pin of the GSM module. The TXD pin of GSM module is connected to RX pin of the Arduino and RXD of the GSM module is connected to the TX pin of the Arduino board for serial communication. Here the data coming from GPS is extracted by the Arduino and is given to GSM module. The GSM module is responsible for sending the data to the internet.

b. Usage in the Switchover Unit

The connection between GSM module and other components of switchover unit is shown in figure 1.6. The GSM module in switchover unit does the same function as that in the vehicle unit. The interfacing between Arduino board and the GSM module is also similar to that in the Vehicle unit.

TCP connection establishment

This is the most important part among all. The connection between SIM900 and the web server is established by using the AT commands. The AT commands are given through Arduino programming. The important AT commands used and their functions are listed in the following table.

AT commands and their Syntax	Functional Description	Response of the GSM module to AT commands and their meaning.
AT	Used for testing the GSM i.e whether it is responding to AT commands or not.	OK→Responding to AT commands
AT+CPIN	It checks whether the SIM is unlocked or not.	+CPIN:READY→ SIM is unlocked
AT+CREG	It checks whether the SIM is registered or not.	+CREG:0,1→ The SIM is registered.
AT+CGATT	IT checks whether the SIM is attached to GPRS service or not.	+CGATT:1→ Attached to GPRS service.
AT+CIPSHUT	It resets the IP session.	SHUT OK→ All IP sessions are shut down.
AT+CIPSTATUS	It checks whether the IP stack is initialized or not.	STATE:IP INITIAL→ The IP stack is initialized.
AT+CIPMUX=0	It is used to ensure single connection mode.	OK→ the single connection mode is set.
AT+CSTT= ”APN NAME”,”USER NAME”,”PASSWORD”	It sets the APN, user name and password. The APN, User name and password is different for different type of SIM card. It is provided by the service provider.	OK→ The APN, User name and password set properly.

AT+CIICR	It brings up wireless connection. It takes some time to give response.	Ok→ Wireless connection has been established.
AT+CIFSR	It is used to get the local IP address i.e the IP address of the device used.	"aaa.aaaa.aaa.aaa"→ It is the IP address of the device used.
AT+CIPSTART="TCP", "server IP"," Port number"	It establishes the TCP connection with the web server whose IP address is provided here. The port number is the TCP application port number of the server.	CONNECT OK→ The connection has been established.
AT+CIPSEND	It sends a request to the server for data transmission.	">"→ It means type your data to send. Now the data is sent in a format so that it can be retrieved from the web server easily.
AT+CIPCLOSE	It is used to close the TCP connection.	OK→ The TCP connection is closed now.

Table 2.6 List of AT Commands Used in TCP/IP Application

Here after giving AT+CIPSEND command, the GSM module will send ">" In response. After that we have to type our data in a predefined format. The data format should be such that the receiving code will extract the data easily. After typing the data we have to press the Ctrl+Z to send the data. Now the GSM module will receive "SEND OK" that means the data has been received at the port of the specified web server. Figure no. shows the response of the GSM module to AT commands given through the Arduino program. The response is viewed on the serial monitor of the Arduino IDE software.

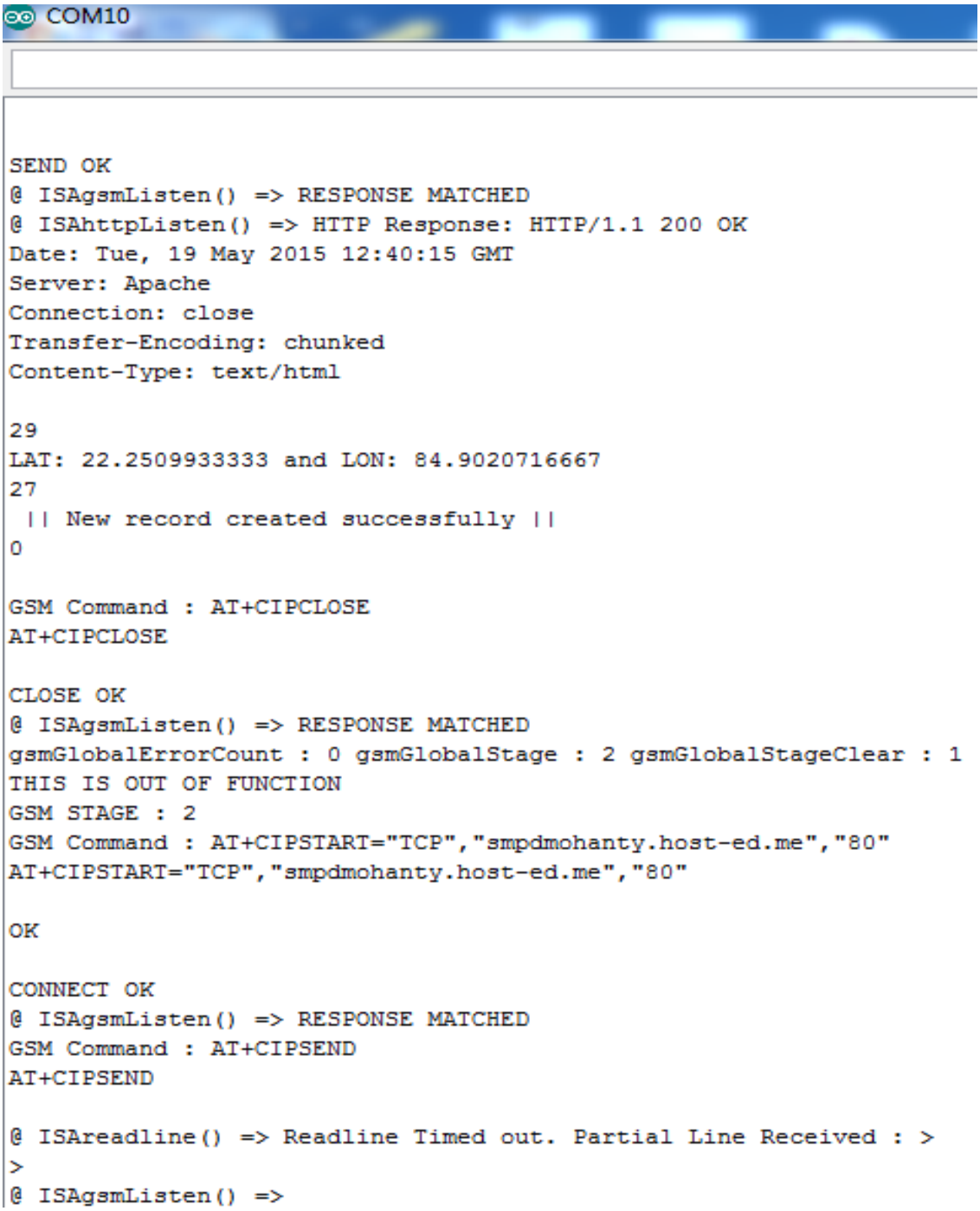


Figure 2.20 Data sending Using GSM shown in Serial Monitor of Arduino

3. DESCRIPTION OF THE SOFTWARE USED

The software used here are

1. Mini GPS Tool
2. XCTU software
3. Arduino IDE software
4. Hyperterminal software
5. Eagle software

3.1. Mini GPS tool

It is the software used for viewing the GPS data. It also extracts the latitude and longitude value from the raw data. First we have to connect the GPS receiver to a USB to serial converter and then the USB to serial converter is connected to a computer through a USB cable. Figure no. shows the latitude and longitude extracted from the raw data of GPS using mini GPS tool.

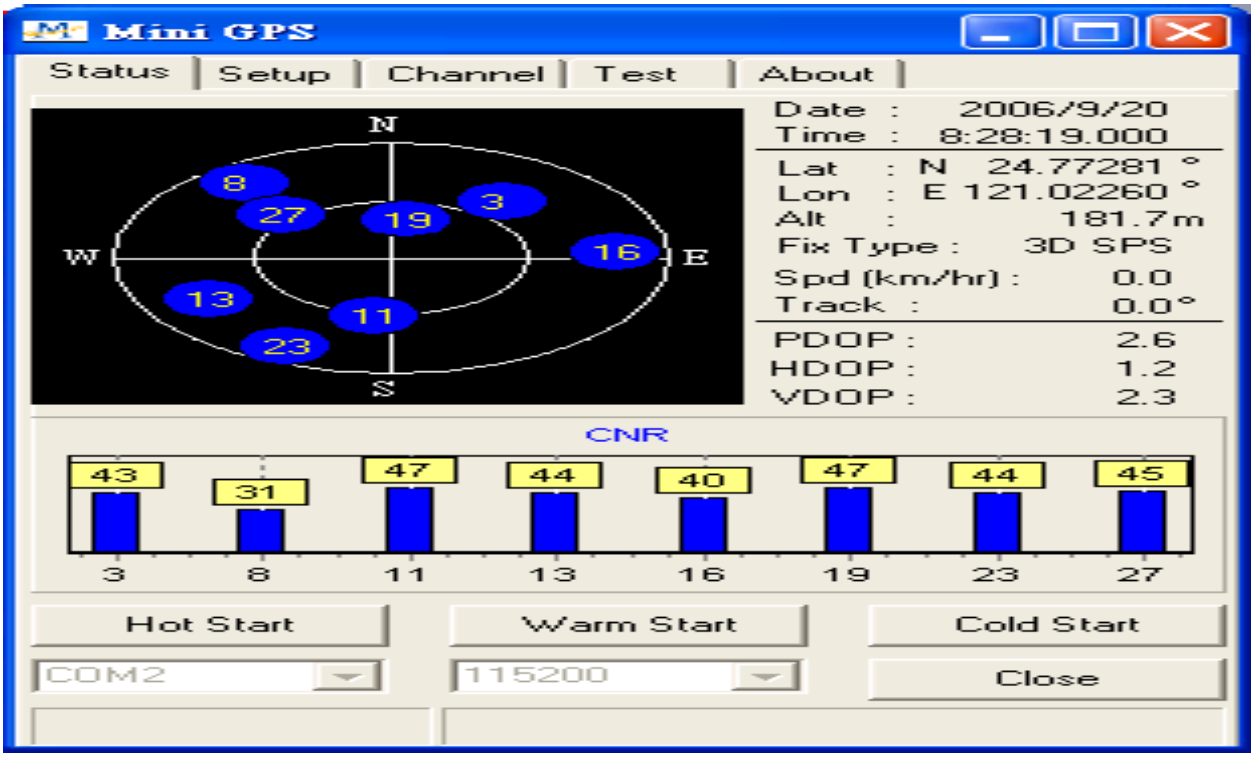


Figure 3.1 Latitude and longitude shown in Mini GPS Tool Software

3.2. XCTU software

As discussed in chapter no. this software is used for configuring the Zigbee devices. Similar to GPS, here also we have to connect the Zigbee device to a USB to serial converter and then the USB to serial converter is connected to a computer. All the settings of a Zigbee device is done by using this software. Figure no. shows the main window of the XCTU software. We connect two Zigbee devices to a single computer and can see the data transmission between these two devices by using this software. The range test can also be done using this software.

3.3. Arduino IDE software

It is the software where all the codes are written. The following steps are followed to upload a program in Arduino board using Arduino IDE software.

1. The Arduino IDE software is first downloaded.
2. The Arduino board is connected to the computer using a USB cable.
3. Note down the COM port and open the software. Then a window will open as shown in figure no.
4. Click on tools and then set the board as Arduino Mega 2560 and the COM port as noted before.
5. Write the program on the window and then click the verify button.
6. If error is not in the program, then you can upload it by using the upload button.

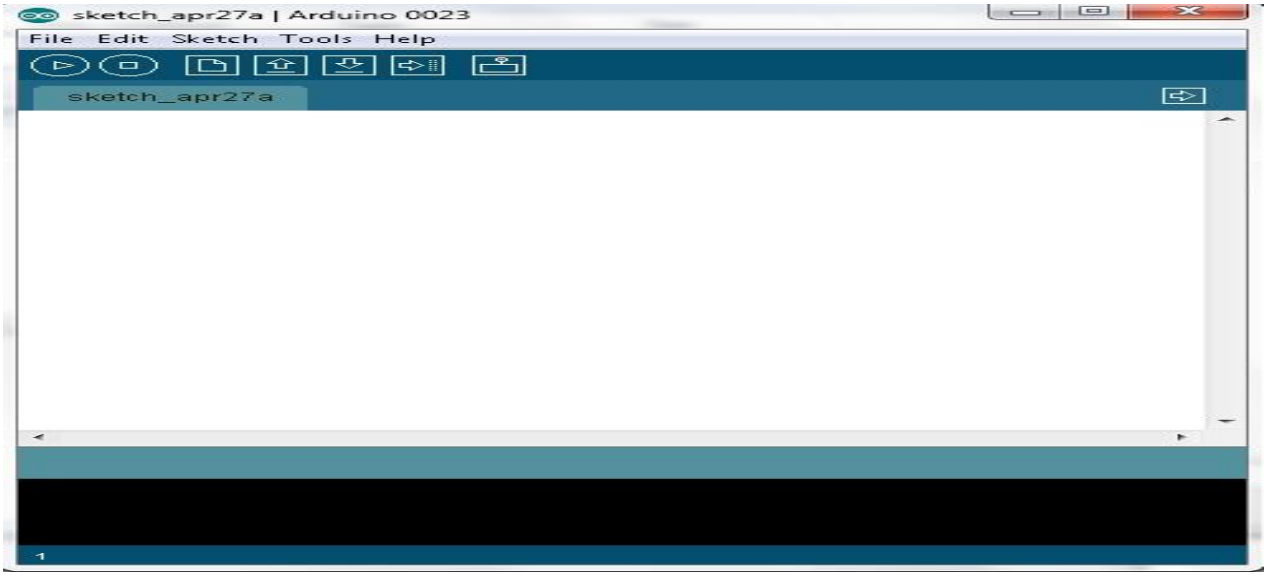


Figure 3.2 Arduino Window

3.4. Hyperterminal software

This software is used for testing the GSM module. It is basically used for displaying the response of GSM module to AT commands. To view the response first we have to connect the GSM module with a USB to serial converter and the USB to serial converter is connected to a computer having hyperterminal software through a USB cable. Now note the corresponding COM port and then open the Hyperterminal software. When we open the Hyperterminal software it will ask for a new connection. The COM port number is then set to the number noted before. The baud rate of the GSM module and that of the Hyperterminal software must be matched for better communication. Figure no. shows the response of the GSM module to AT commands displayed using Hyperterminal software.

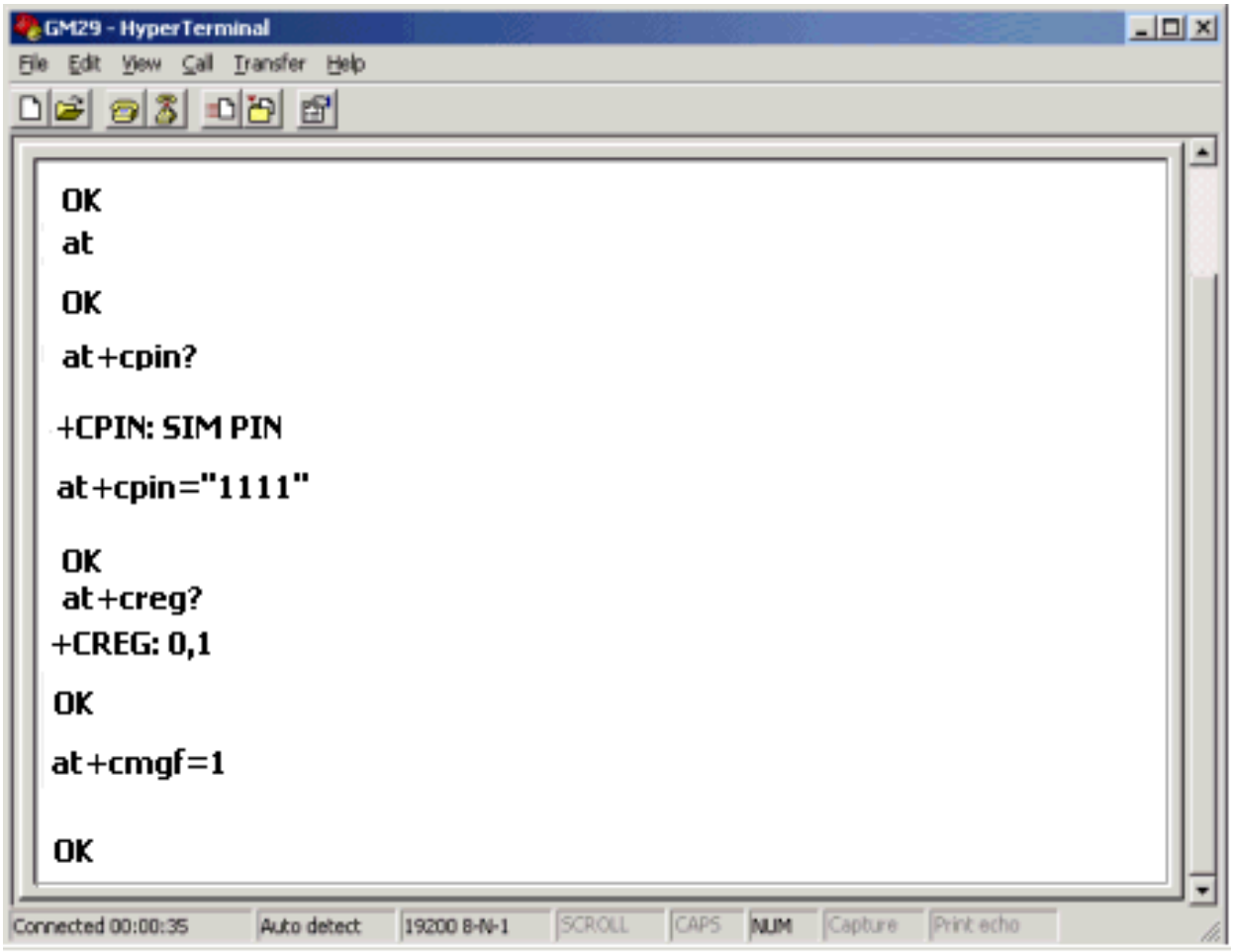


Figure 3.3 Hyperterminal Software

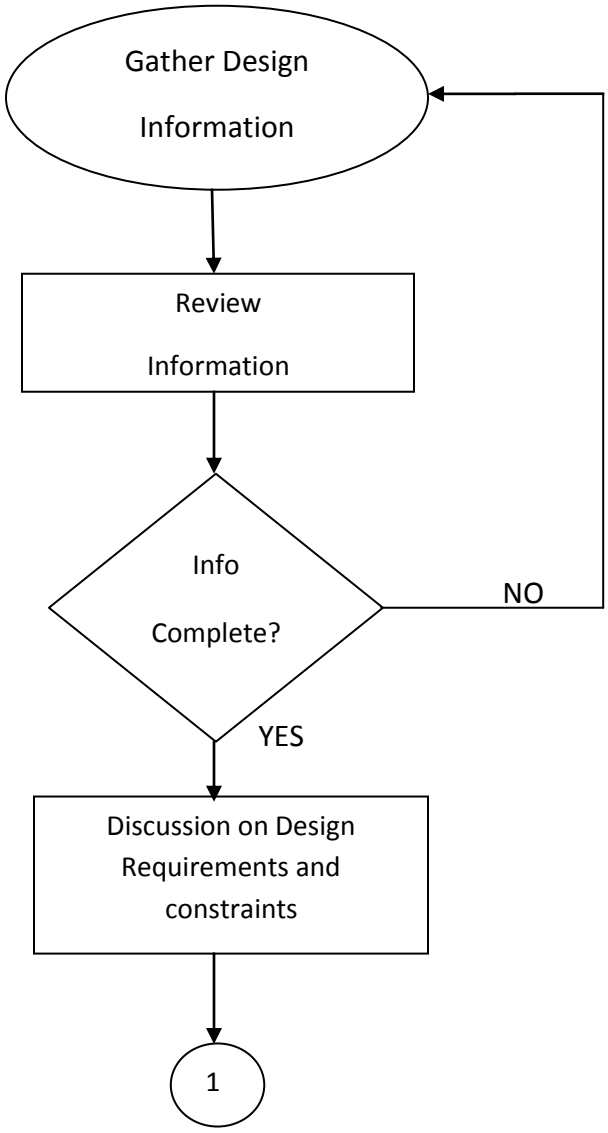
3.5. Eagle software

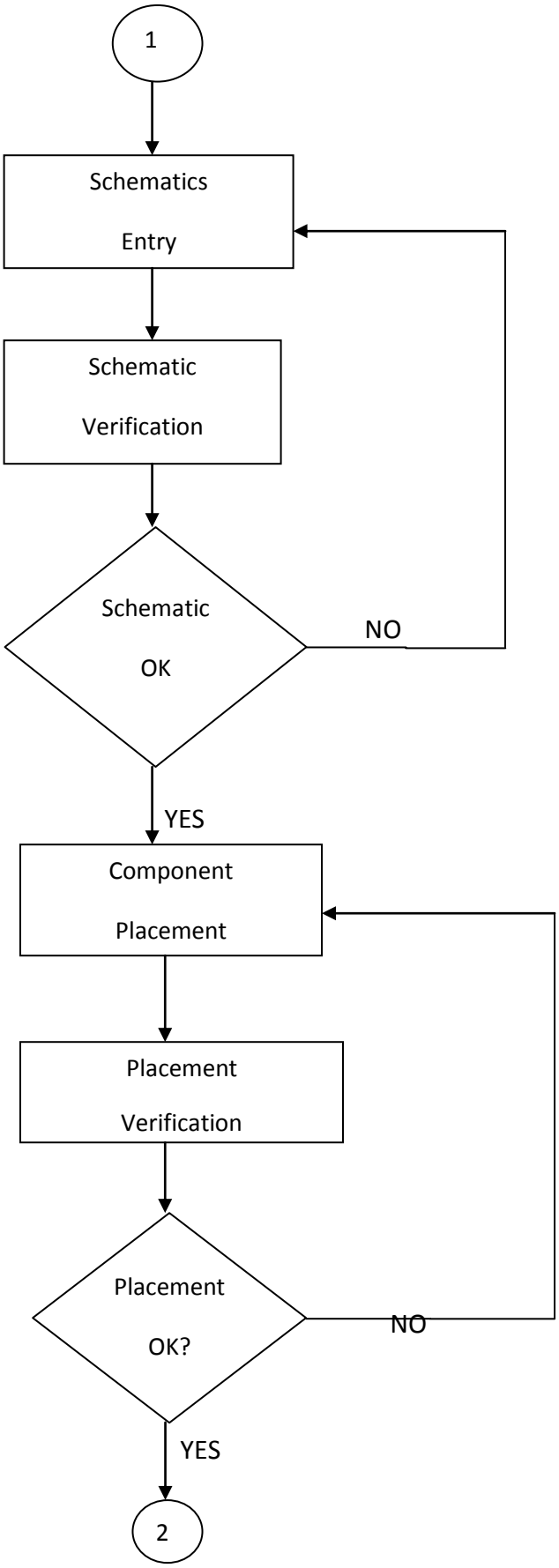
The Eagle software is used for PCB design. The version of Eagle used here is EAGLE 7.1.0. It consists of Schematic editor, Layout editor and library editor. The schematic editor is used to do the schematic of the design. The layout editor is used to do the placement and routing. The library editor is used to create new components. The detail description about EAGLE software is given in chapter no.4.2.

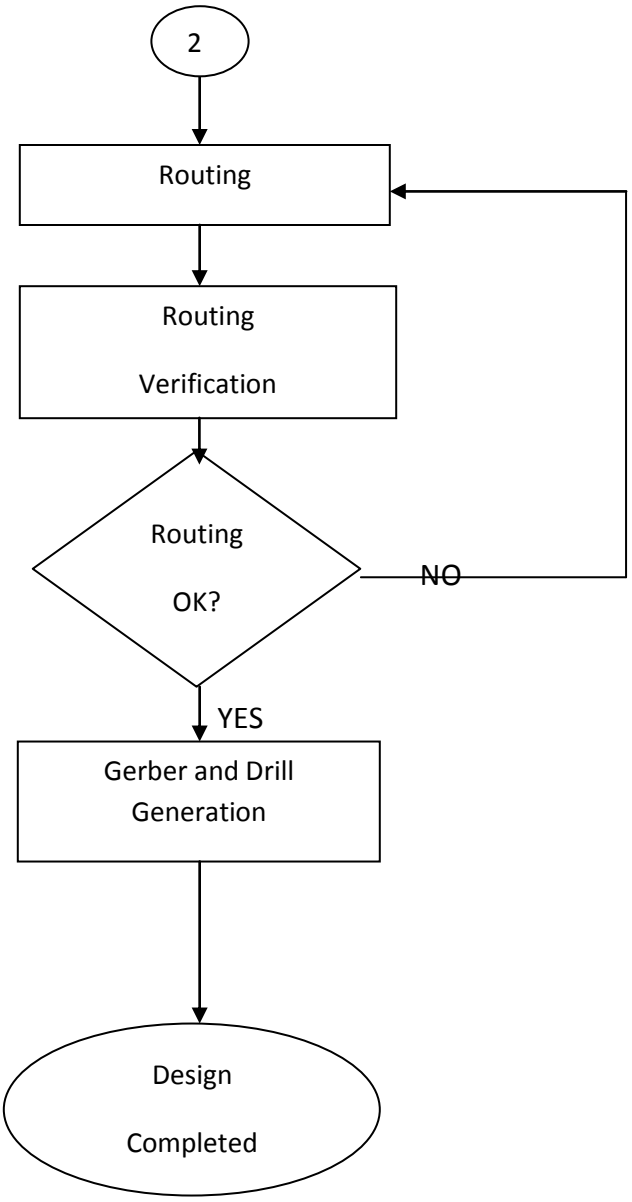
4. PCB DESIGN

4.1. Basic concept

The PCB design is basically done to reduce the size of a particular product's prototype. It also reduces the cost of the complete product. The prototype of a product combines all the functional modules and uses some of the parts of the modules as per the requirement. But all the unused part of different modules increases the size of the prototype. The individual modules used in the prototype are also having more cost. A single board can be fabricated by using all the required components and doing proper connections between them. In doing this, the cost of the product as well as size will also be reduced because, all the unused components of different modules will be removed and used components are placed on a single board. There are several software for doing PCB design. Whatever may be the software used the design flow will be same for all, which is as follows




1
Schematics
Entry
Schematic
Verification
Schematic
OK
NO
YES
Component
Placement
Placement
Verification
Placement
OK?
NO
YES
2



4.2. Eagle software

The software used here is eagle 7.1.0. In Eagle software we have to add predefined libraries. There are many predefined libraries in which footprints almost all the electronic components, ICs, Batteries etc. are present. Components with different types of footprints such as SMD, through hole etc. are also available in these predefined libraries. If any component is not present in these predefined libraries then we have to create that new component. For creating a new component we have to first define the library, then we have to create the symbol and then the layout. After that we can add this component in the library list. There are three main tasks we have to perform while designing a PCB using Eagle software.

1. Schematic
2. Layout
3. Gerber Generation

4.2.1. Schematic editor

The schematic window of Eagle is shown in figure no. It consists of many button using them we can do our design schematic. The schematic is done by adding the required components from different libraries. The components are connected electrically by using the wire/net available in the schematic editor. Here the placement of the components is not important. The important job is to connect the components correctly. After doing proper schematic we can to layout editor by clicking on the “switch to board” button.

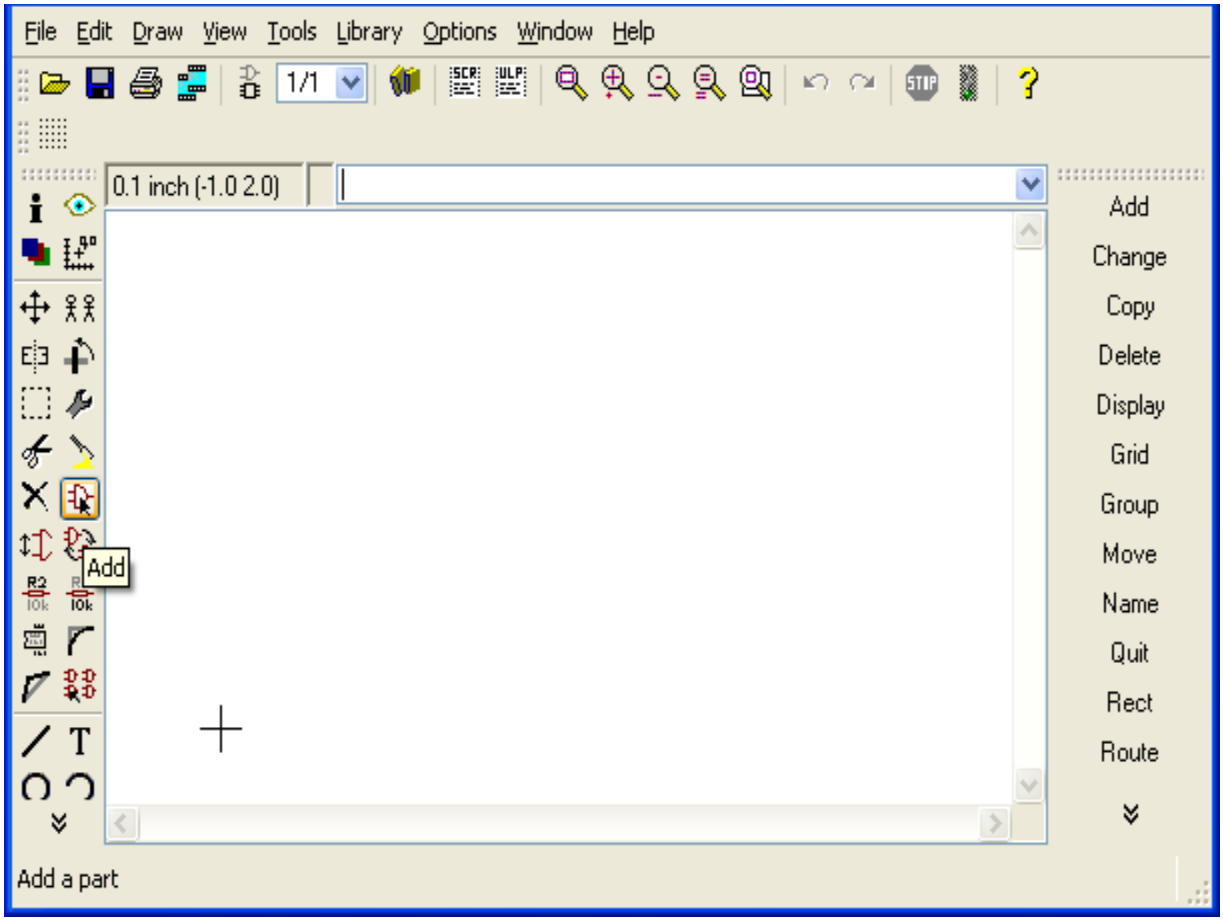


Figure 4.1 Eagle Schematic Editor

4.2.2. Layout editor

After clicking in “switch to board” button in schematic editor, the layout editor will open. In layout editor the components used in the schematic will appear in the form of their layouts. The components connected electrically in schematic editor will also be connected accordingly in the layout editor. In layout editor we have to perform two tasks. One is placement and the other one is routing. In placement, we have to place the components in a proper manner such that the size of the board will be small and routing will be easy. Basically in placement, the components which are electrically connected are placed nearer to each other. In routing, the air wire connections are turned into cupper connection. The routing can be made easy by using multilayer PCB. In multilayer PCBs, the layers are connected by using the vias at required places. The placement and routing is done in such a way that they should obey the design rules of Eagle software. Figure no. shows the Layout editor just after switching from schematic editor. The components are placed only within the rectangular box provided.

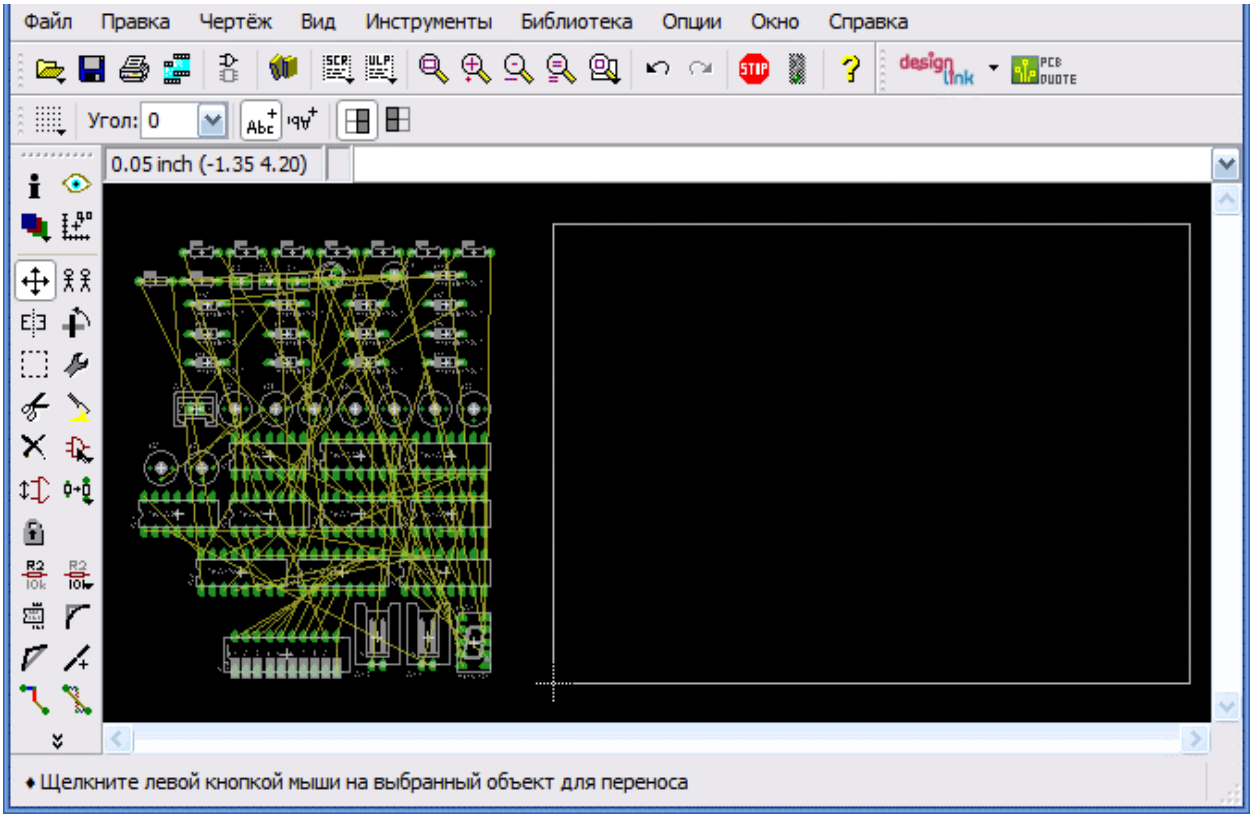


Figure 4.2 Eagle Layout Editor

4.2.3. Gerber generation

After doing proper placement and routing the next step is to generate the Gerber files. These are files sent to the manufacturer for fabricating the board. Following table shows the Gerber files and their extensions.

GERBER FILE	EXTENSION
Bottom Cupper	GBL
Top Cupper	GTL
Bottom Silkscreen	GBO
Top Silkscreen	GTO
Bottom Soldermask	GBS
Top Soldermask	GTS
Drill File	TXT
Drill Station Info File	drd
Photoplotter Info File	gpi
Mill Layer	GML
Top Paste	GTP

Table 4.1 List of Gerber Files

4.3. Designed PCBs

Here two PCBs are designed (Not soldered) one is for Vehicle unit and the other one is for switch over unit. A shield will be created for both the units. Above the shield GSM will be attached and below the shield Arduino board will be attached so that the size of the units will be reduced.

4.3.1. PCB for vehicle unit shield

a. Schematic of the shield

The schematic of the vehicle unit shield is shown in the figure no. the schematic shows all the components and required electrical connections. The PCB of the vehicle unit shield consists of following parts.

1. Pin headers
2. Power supply Unit
3. GPS Unit
4. Zigbee Unit

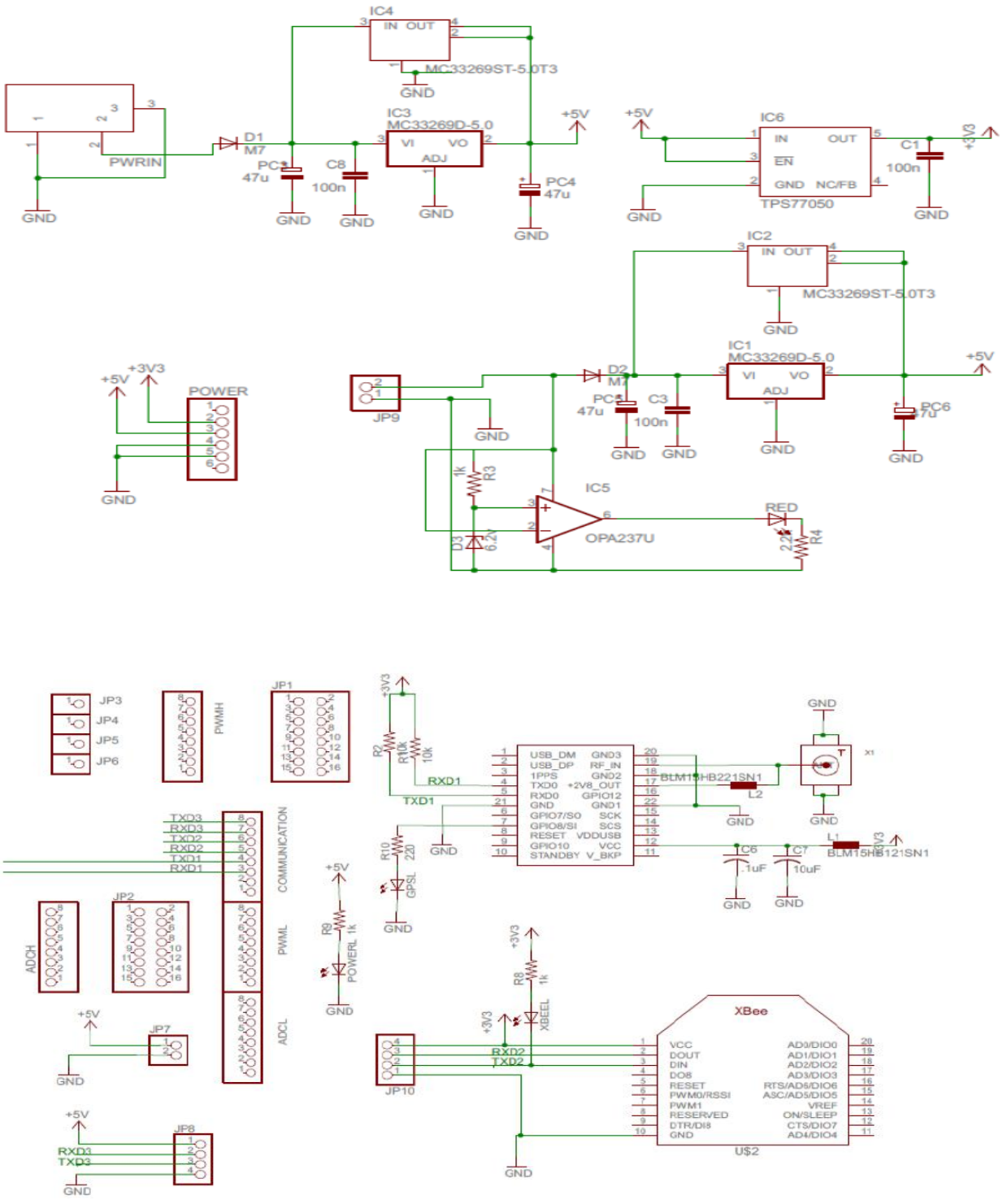


Figure 4.3 Schematic of Vehicle Unit Shield

Pin headers

The shield will be such that it will fit to Arduino Mega 2560 board. There are two 16-pin pin headers, five 8-pin pin headers, one 6-pin pin header. These pin headers are placed in such a way that the Arduino Mega 2560 board will be attached at the bottom of the shield. Other pin headers are also there which are used as power supply pins.

Power supply unit

Power can be supplied to the shield through battery and also there is a provision of supplying through adapter. For supplying power using battery, one pin header with two pins is provided and for supplying power through adapter one power jack is provided. The circuit consists of two 5V voltage regulators and two 3.3V voltage regulators. One 5V regulator and one 3.3V regulator will take the input from battery and the other pair will take it from the adapter. One extra 3.3V voltage regulator is also there, which provides less output current. The Arduino board and GSM will also take the power from supply. A 4-pin pin header is there for supplying power to Arduino and a 2-pin pin header is for GSM. The Arduino board needs more supply current. So to meet this requirement the output of the 5V regulator and the 3.3V regulator are connected as shown in figure no. there is a power LED indicating that the module is getting power or not.

While providing power through battery, the battery may goes below some voltage level and may not be able to supply required power. So there is a voltage low indication circuit. The voltage low indication circuit consists of one comparator, one Zener diode and one LED. The inverting input of the comparator is connected to the positive terminal of the battery and its non-inverting terminal is connected to Zener diode whose Zener voltage is 6.2V. When the battery level goes below 6.2V, the output of the comparator goes high and the LED connected to the output of the comparator will glow.

GPS unit

It consists of the SKG13C GPS chip. To indicate the status of the GPS i.e whether the GPS receiver is receiving valid data or not one LED is present. The LED will blink when the GPS is locked. Two 10K resistors are there to pull up the TX and RX pin. The pull up of these pins increases data stability. There are two ferrite beads used here. One of these ferrite beads is

used for providing noise free power supply to external antenna and the other one is used for providing noise free power back up. One RPSMA connector is there for connecting external GPS antenna.

Zigbee unit

It consists of the Zigbee module. An LED is there to indicate the availability of power to Zigbee module. A 4-pin pin header is also there for interfacing the Zigbee with other devices.

b. Layout of vehicle unit shield

The layout of the vehicle unit shield is shown in figure no. Here two tasks are need to be performed. One is placement and the other one is routing.

Placement

In placement all the components are placed in such a way that the size of the board will be small and routing will be easy. Here the pin headers are placed according to the Arduino Mega 2560 board. The antenna connectors are placed near the edges of the board. The components which are connected electrically are placed nearer to each other. The components that are placed nearer to the edges of the board are placed in such a way that they will not violate the design rules. Here the LEDs are placed at one side of the board so that it will be visible after connecting the Arduino board and the GSM module. The power jack is also placed near the edge of the board so that connecting it with DC Adapter will be easy.

Routing

It is the complex part of the PCB design. Here the components connected electrically with each other. The shield designed here is a two layer PCB i.e a layer of cupper at the top and a layer of cupper at the bottom. By increasing the layers of PCB routing becomes easy and it will easily obey the design rules. The top layer and bottom layers are connected whenever required. These layers are connected by using vias.

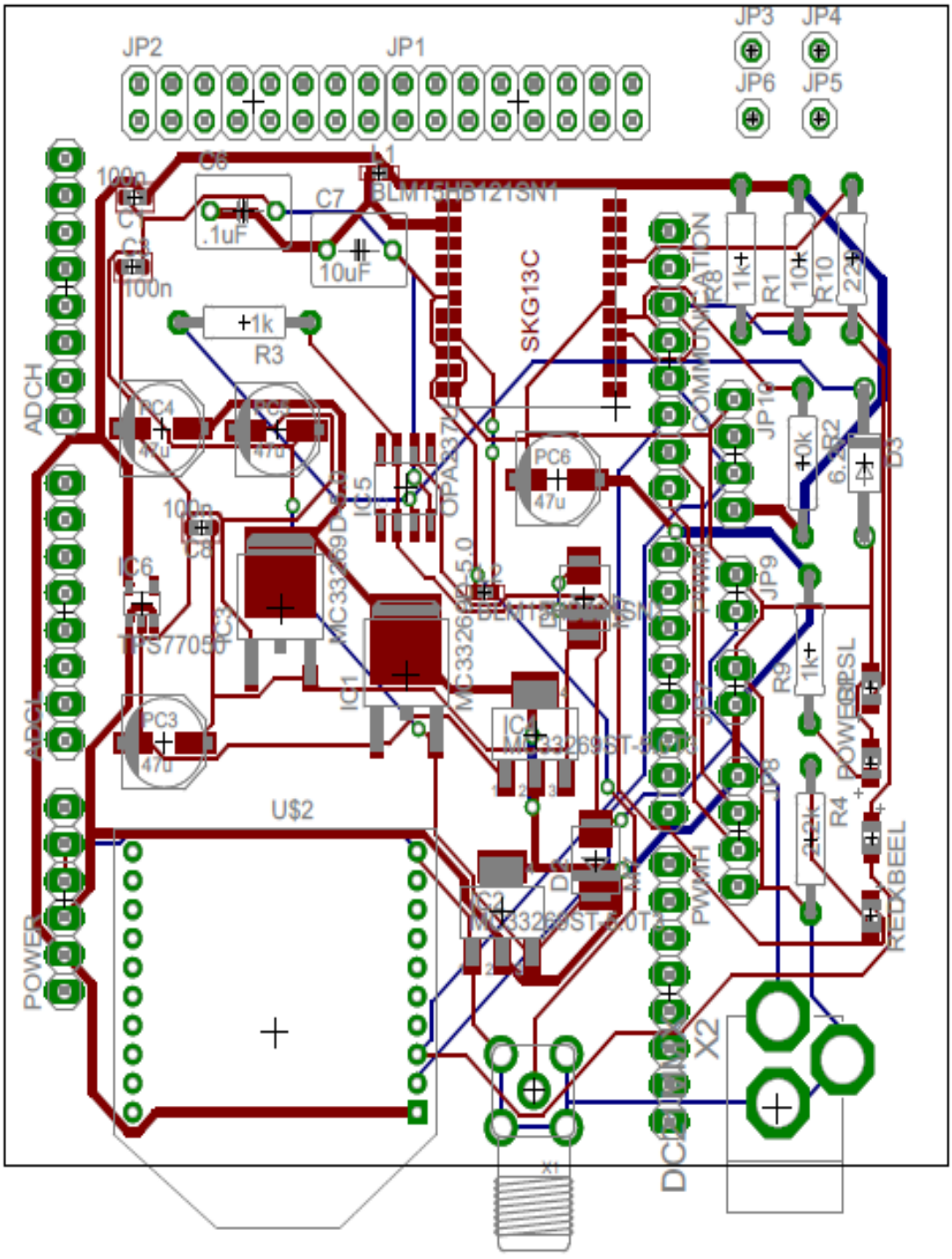


Figure 4.4 Layout of Vehicle Unit Shield

4.3.2. PCB for switchover unit shield

Like vehicle unit here also a shield is created above which GSM will be attached and below Arduino board will be attached.

a. Schematic for switchover unit shield

The schematic for switchover unit shield is shown in figure no.. It is similar to vehicle unit shield except that here GPS unit is absent. It also consists of pin headers, Power supply unit and Zigbee unit. The functions of all these units are same as that of vehicle unit shield.

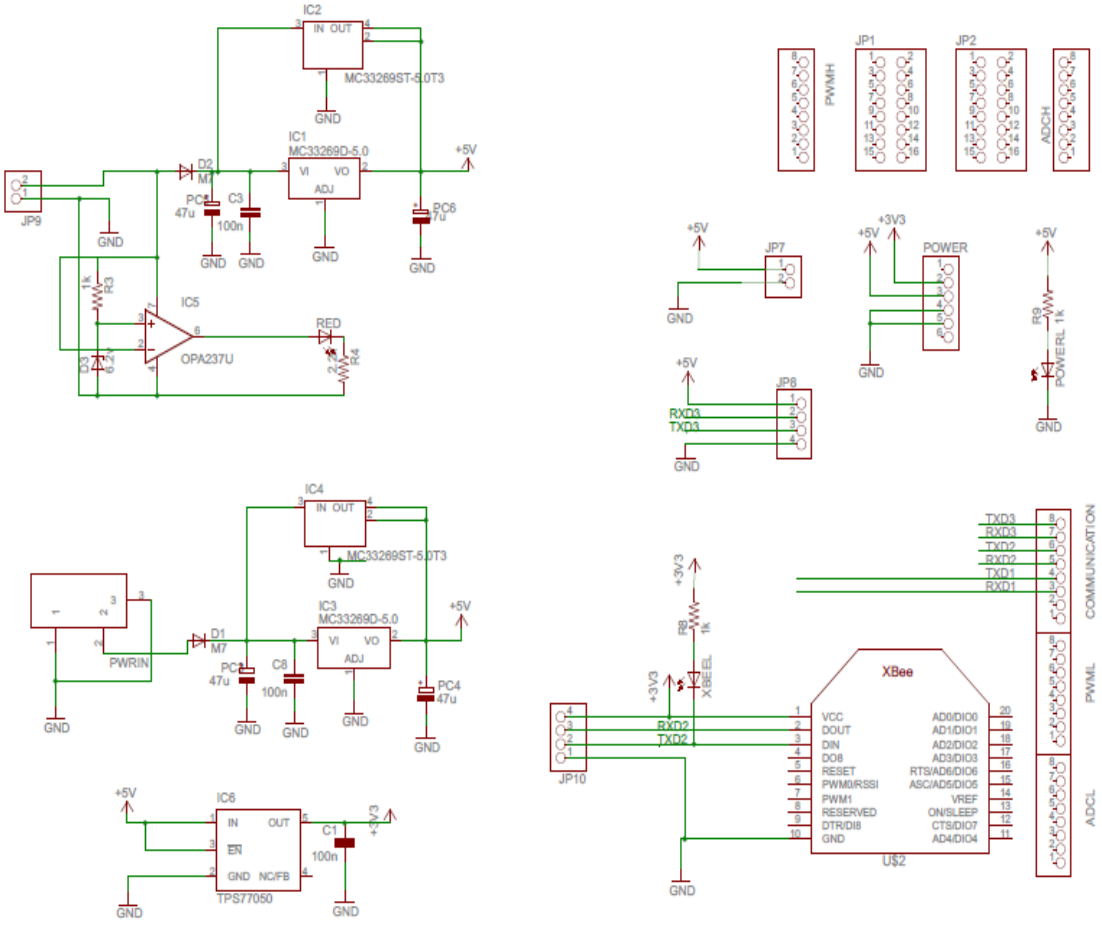


Figure 4.5 Schematic of Switchover Unit Shield

b. Layout for switchover unit shield

The layout of switchover unit shield is shown in the figure no.. It is also a two layer PCB i.e a layer of cupper at the top and a layer of cupper at the bottom.

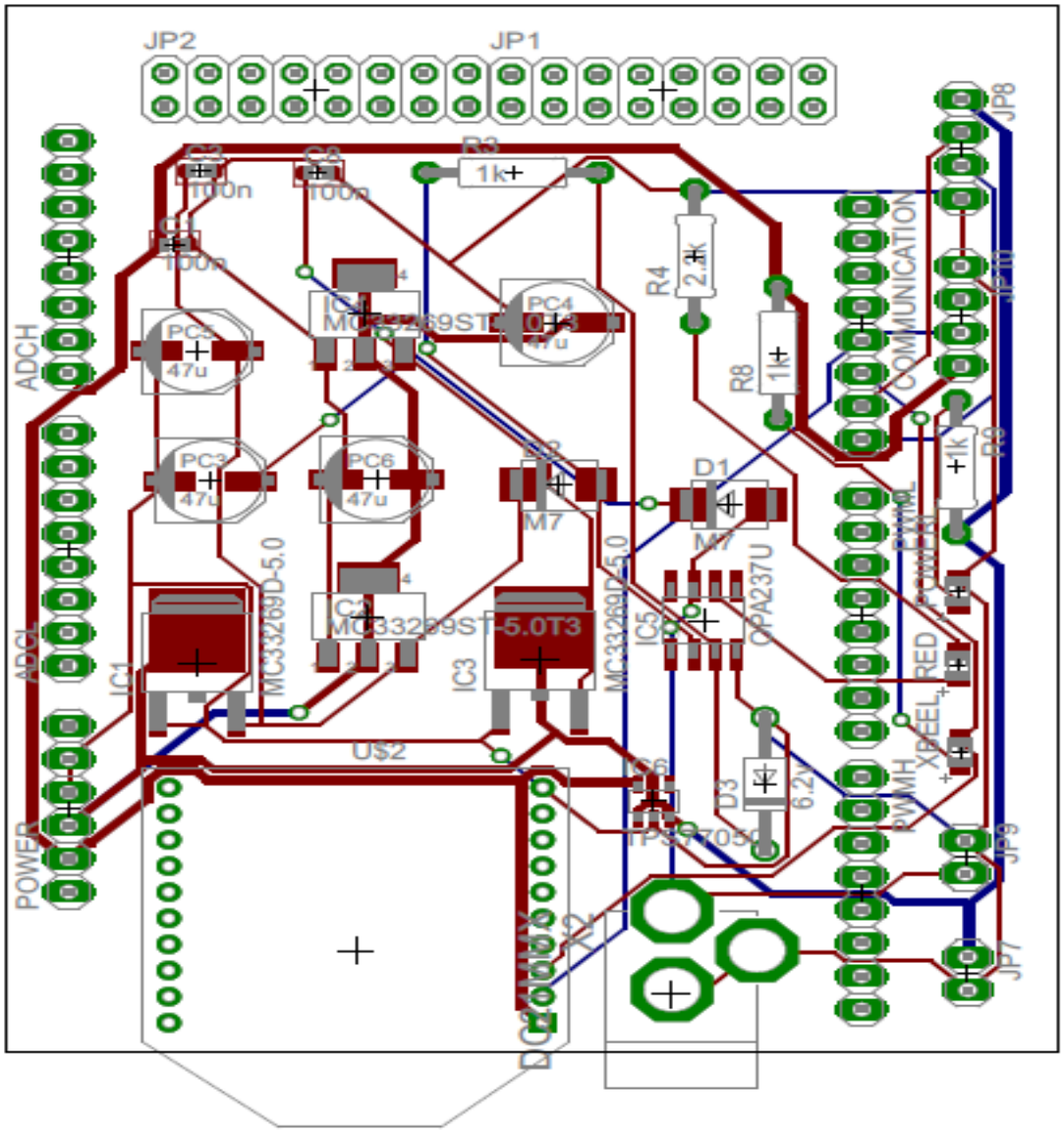
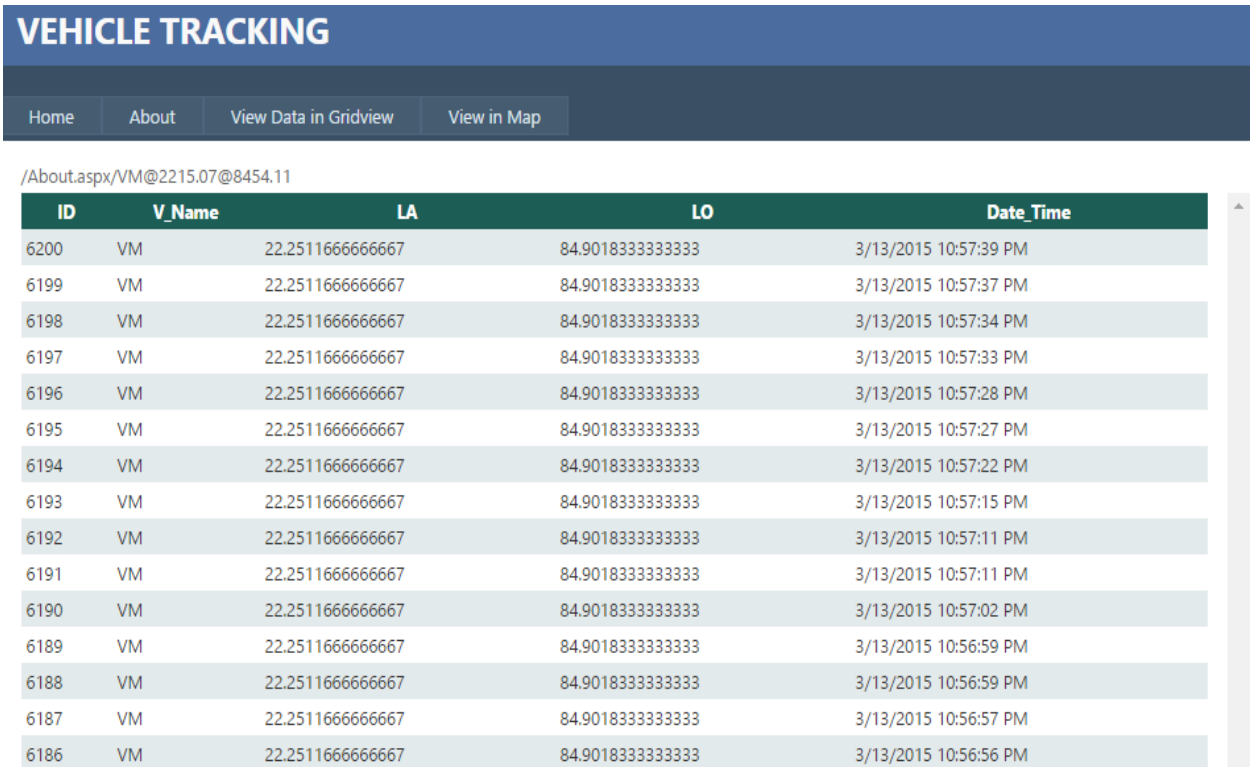


Figure 4.6 Layout of Switchover Unit Shield

5. TESTING AND RESULTS

As discussed earlier first the location and timing information is obtained from the satellites and then the required information is extracted from the information received from the satellite. Now the Vehicle's location information and the Vehicle ID are sent to the web server by using GSM/GPRS network. The TCP/IP communication is used sending the data to web server. The web interface is written in PHP and is executed to associate with a database. The geographic coordinates and the Vehicle ID are stored in this database. A graphical information system has been created to display the vehicle location on the Google map.

5.1. Web server testing



ID	V_Name	LA	LO	Date_Time
6200	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:39 PM
6199	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:37 PM
6198	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:34 PM
6197	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:33 PM
6196	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:28 PM
6195	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:27 PM
6194	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:22 PM
6193	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:15 PM
6192	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:11 PM
6191	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:11 PM
6190	VM	22.2511666666667	84.9018333333333	3/13/2015 10:57:02 PM
6189	VM	22.2511666666667	84.9018333333333	3/13/2015 10:56:59 PM
6188	VM	22.2511666666667	84.9018333333333	3/13/2015 10:56:59 PM
6187	VM	22.2511666666667	84.9018333333333	3/13/2015 10:56:57 PM
6186	VM	22.2511666666667	84.9018333333333	3/13/2015 10:56:56 PM

Figure 5.1 Data Shown in Web Server

Figure 5.1 shows the data received in the web server and stored in the database. As shown in the figure the data is received within an interval of 3 seconds which is sufficient to track a vehicle in an opencast mine. Here the test is performed for a single vehicle.

5.2. Viewing in Google map

Figure 5.3 shows the vehicle unit location in Google map. It is tested at the ECE Department of NIT Rourkela. The vehicle unit tested here is not moving. Figure no shows the locations of the moving vehicle on the Google map. It is tested at the iron ore mine, Tensa" Jindal Steel and Power Ltd."

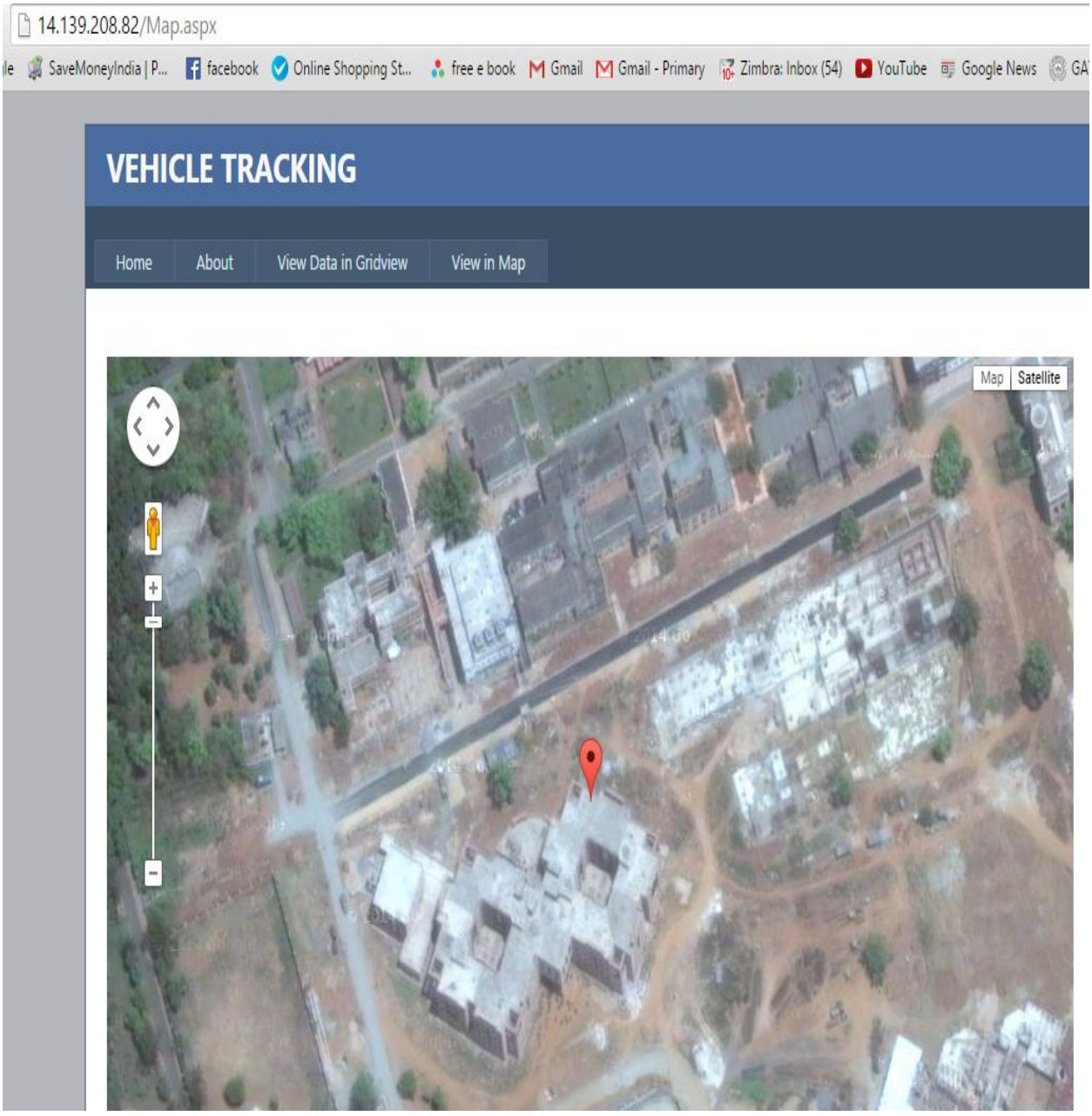


Figure 5.2 Testing at NIT Rourkela

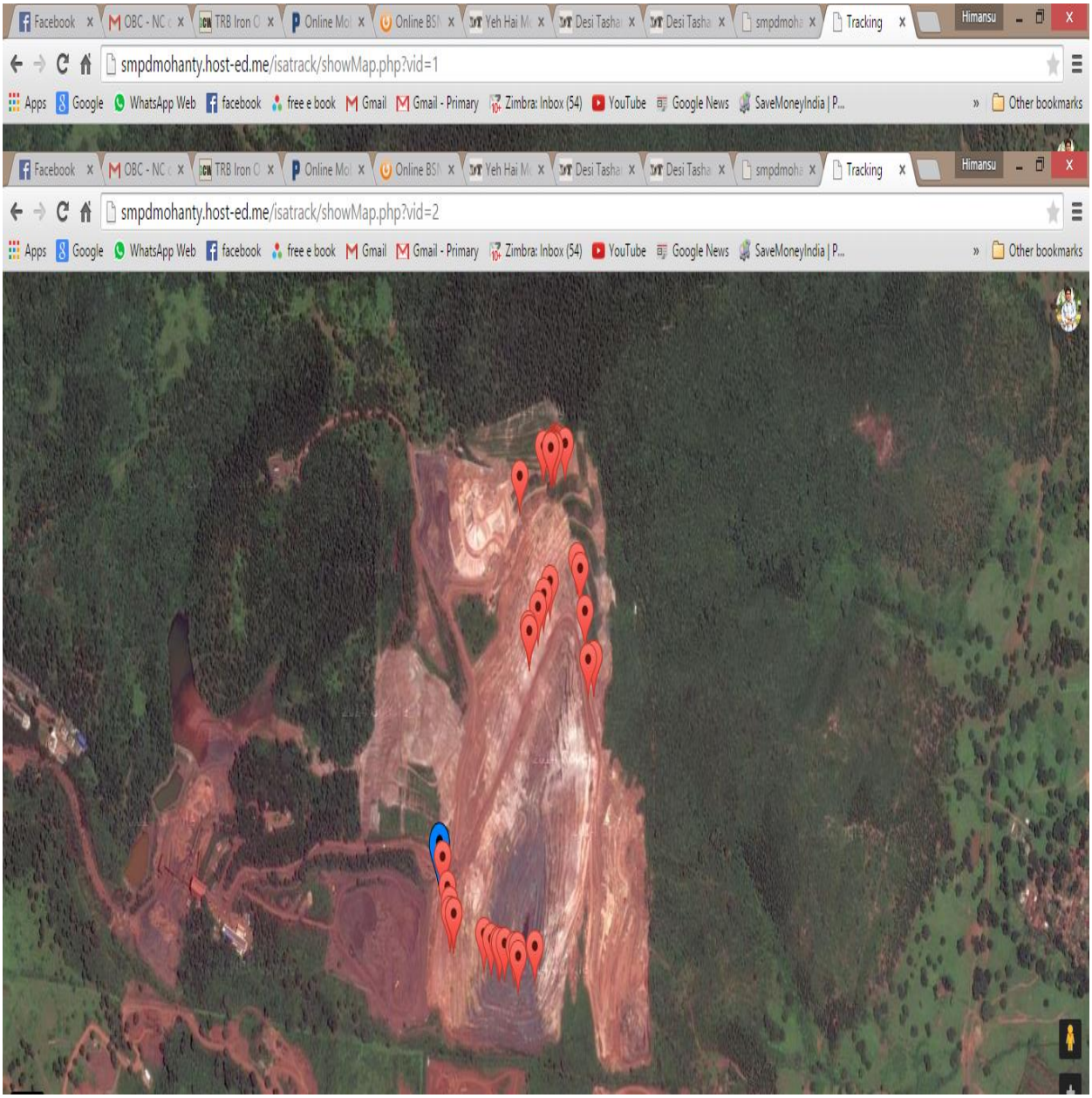


Figure 5.3 Testing at Jindal Steel and Power Ltd.,Tensa.

6. CONCLUSION AND SCOPE FOR FUTURE WORK

6.1. Conclusion

We have implemented and tested a vehicle tracking system, which is tracking the moving as well as the stationary vehicles. The hardware part of the product uses GPS (for receiving location and time information from satellites), Arduino board (as the microcontroller), GSM module (as communication device) and Zigbee/XBee (as communication device). The software of the product includes the software for receiving and storing the data sent by the GSM module and the software for displaying the location of the vehicles. This document describes how the product has been designed, implemented and tested. The product is designed for the iron ore mine of Jindal steel and power Ltd located at Tensa.

6.2. Scope for future work

There is a scope to improve this product in terms of delay minimization. The delay between two successive data coming from the GSM module can be reduced. The size and cost of the complete system can be reduced by removing the unused parts of each module.

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